Electron Scattering

- Hofstadter's experiment for short-lived nuclei -

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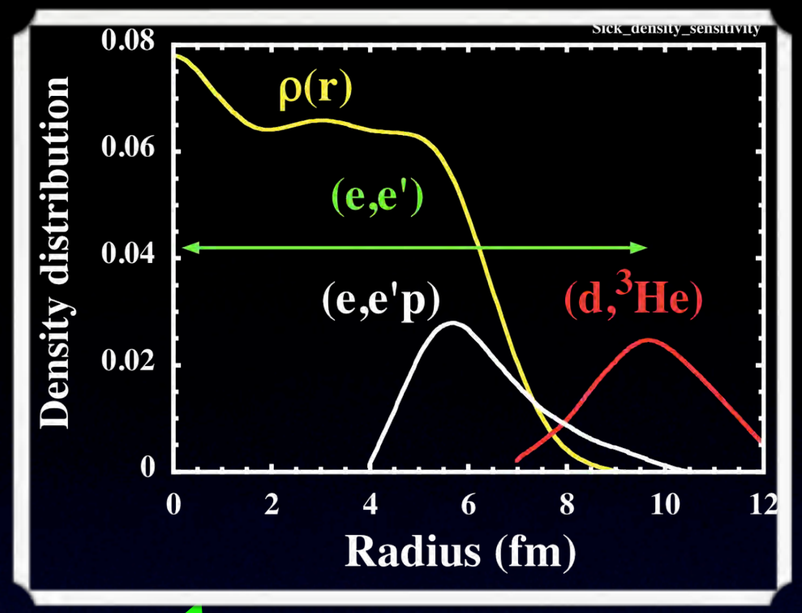
for SCRIT collaboration
(Tohoku, RIKEN, Rikkyo and Nagaka)

electron scattering

1. point particle

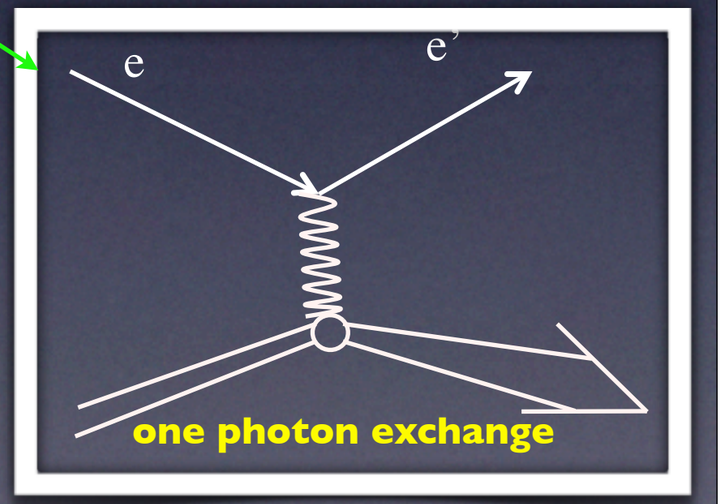
2. electromagnetic interaction

coupling => charge and current
exp. data => structure information
weak => probing the whole volume
perturbation theory



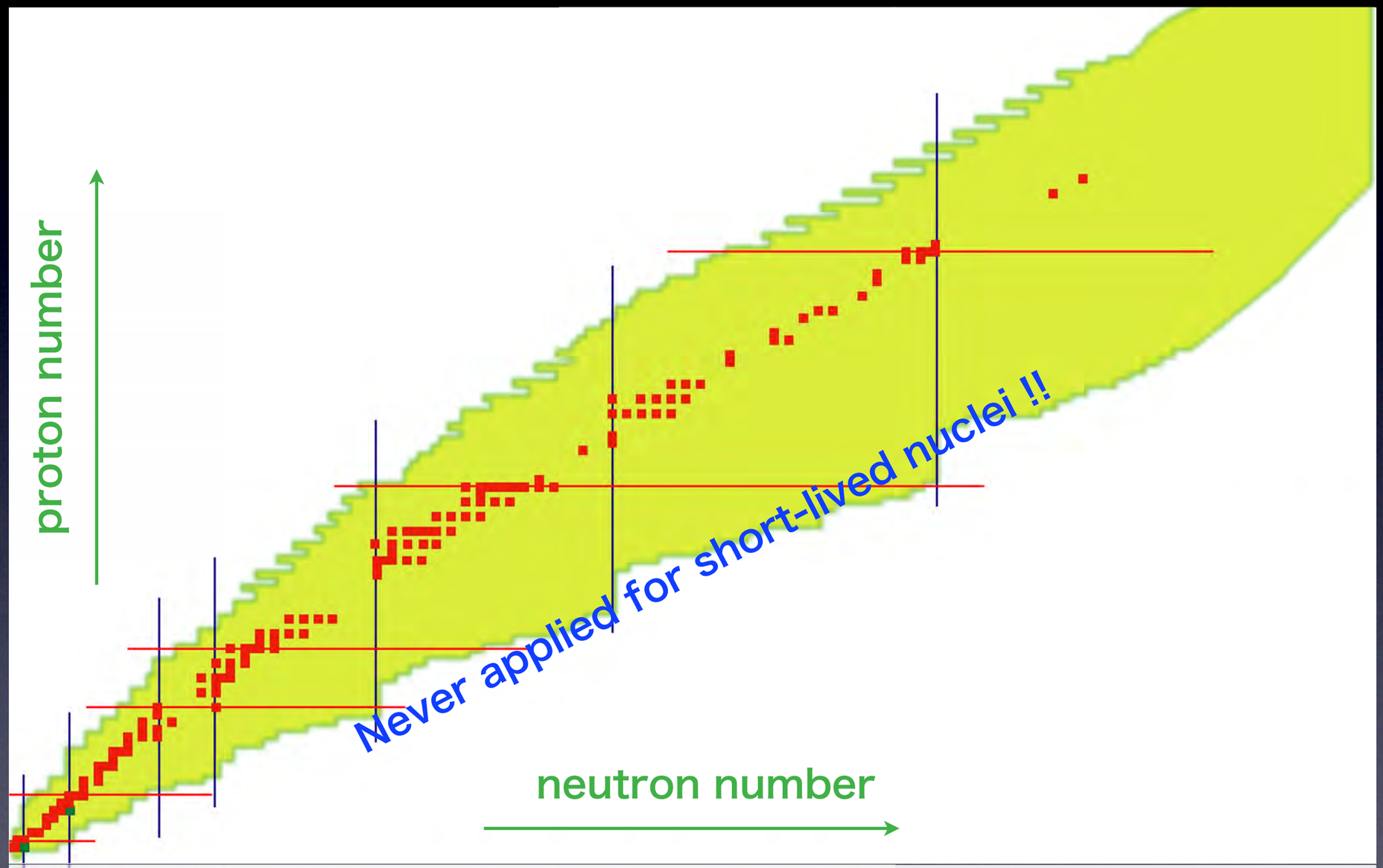
3. varialble q for fixed ω

map out Fourier components
of a specific transition amplitude



the best tool for structure study

Nuclei studied by electron scattering



H.deVries, C. deJager and C. deVries
Atomic Data and Nuclear Data Tables 36 (987)495

elastic scattering for spin-less nuclei

$$\frac{d\sigma}{d\Omega} = \frac{d\sigma_{Mott}}{d\Omega}|F_c(\vec{q})|^2 \quad \Leftarrow \quad F_c(\vec{q}) = \int \rho_c(\vec{r})e^{-i\vec{q}\cdot\vec{r}}d\vec{r}$$

reaction * structure

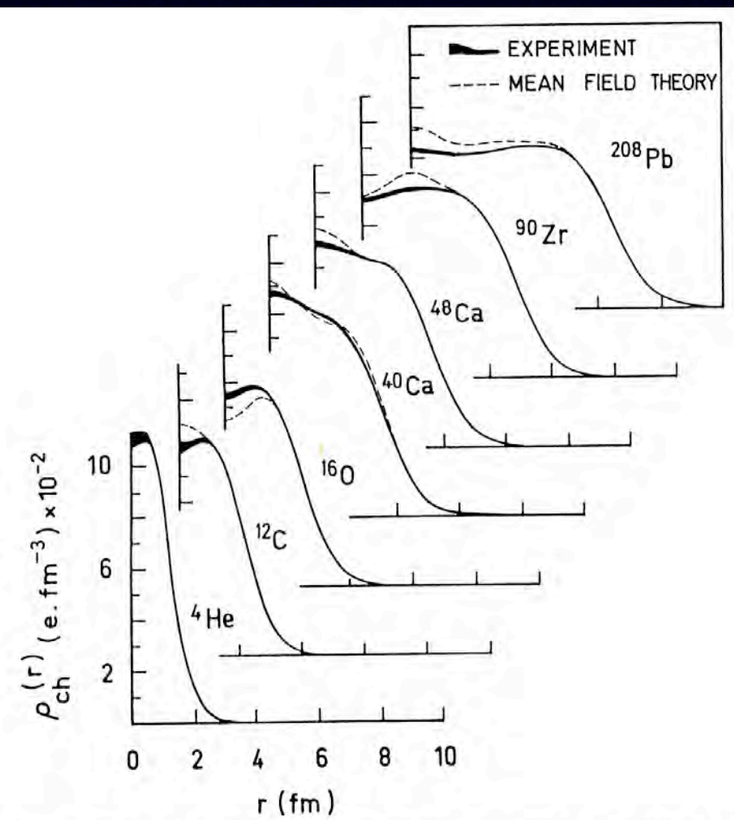


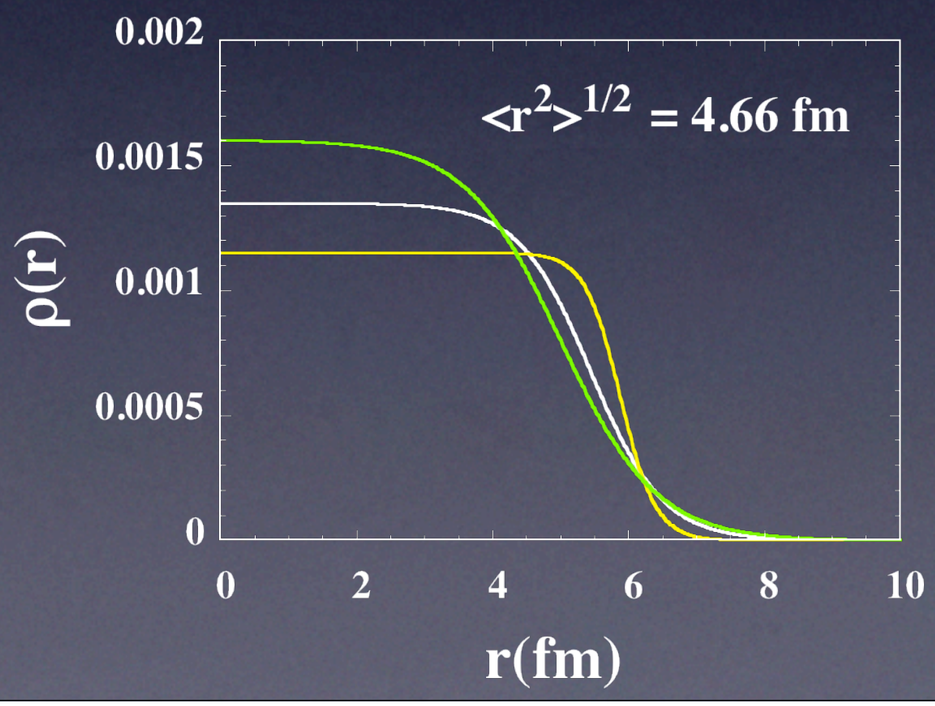
Figure 8 Charge density distributions of doubly closed-shell nuclei. The thickness of the solid line depicts the experimental uncertainty. The mean field calculations are from (53).

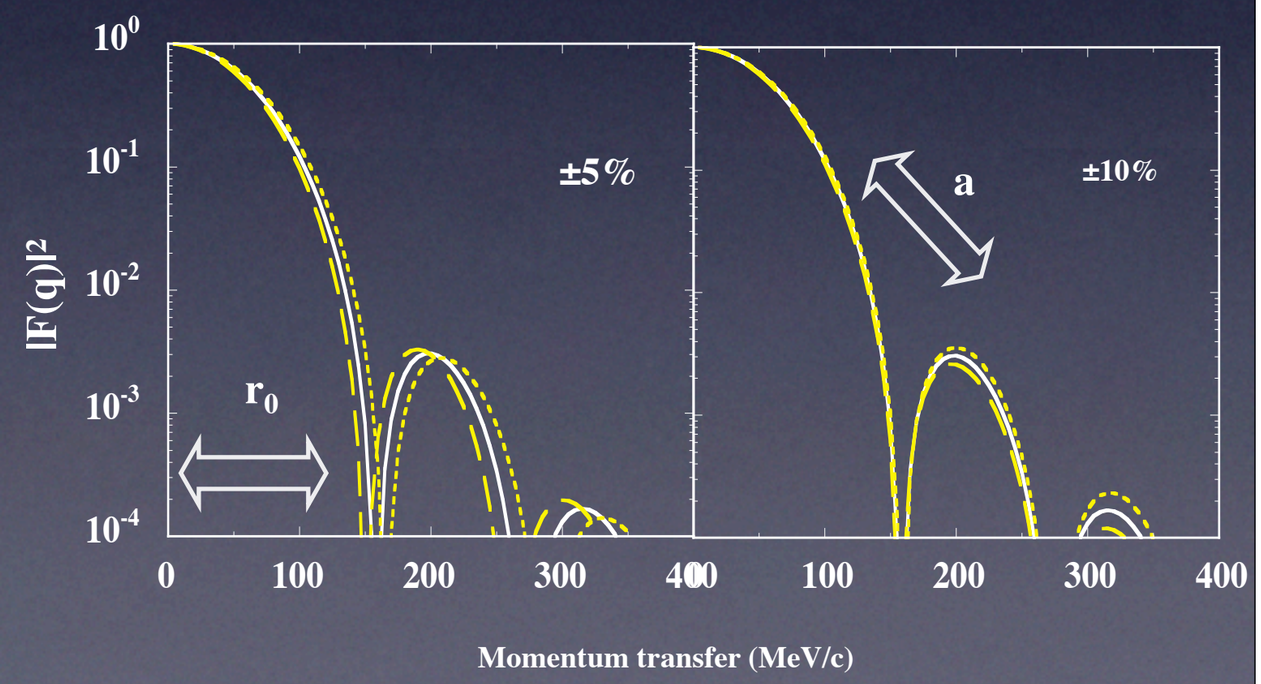
beyond $\langle r^2 \rangle^{1/2}$ ➡ density distribution

$$\rho(r) = \Sigma |\psi_p(r)|^2$$

$$< r^2 > = \int r^2 \rho(\vec{r}) d\vec{r}$$

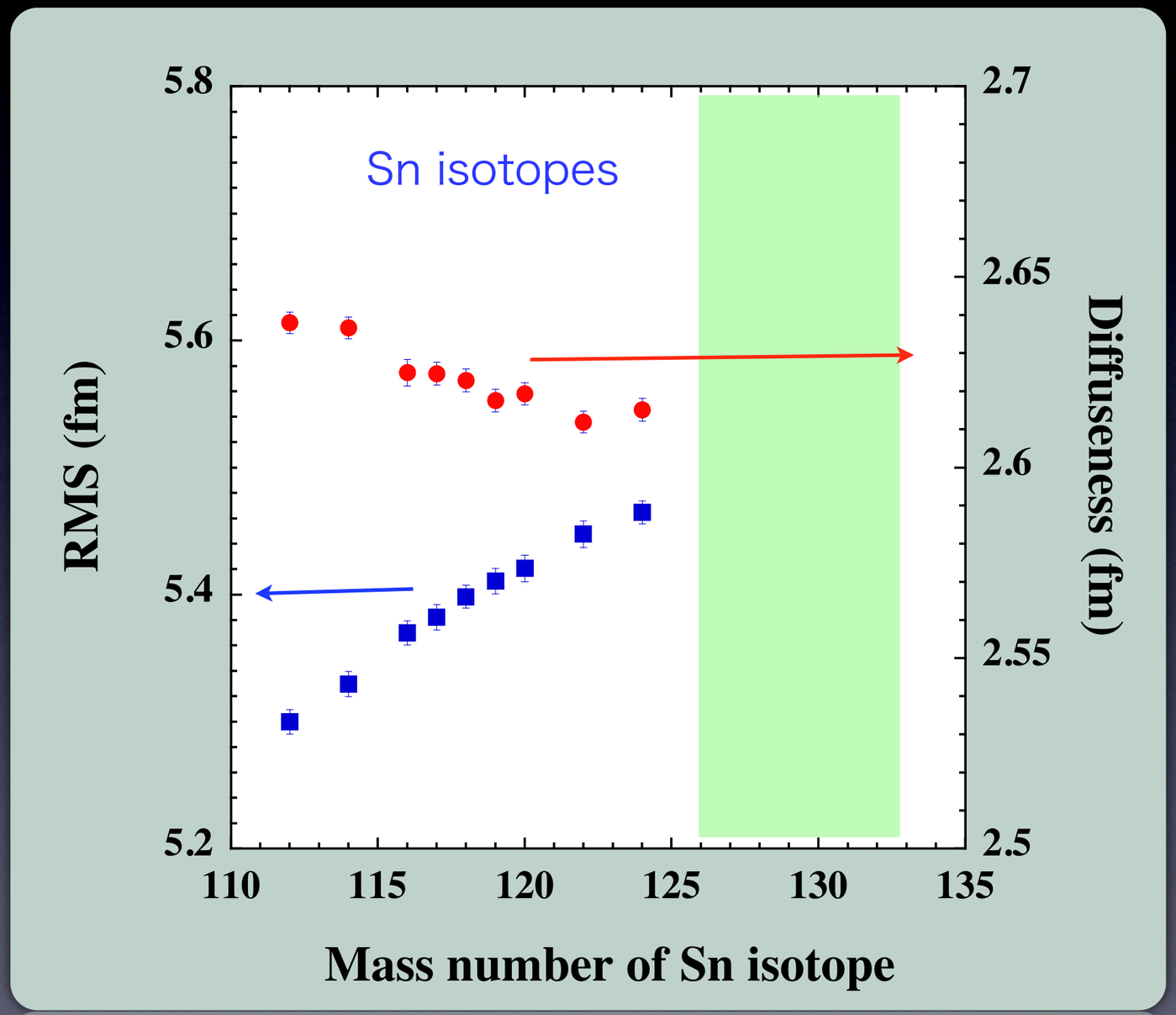
$$\rho(r) = \frac{\rho_0}{1 + exp(\frac{r - r_0}{a})}$$





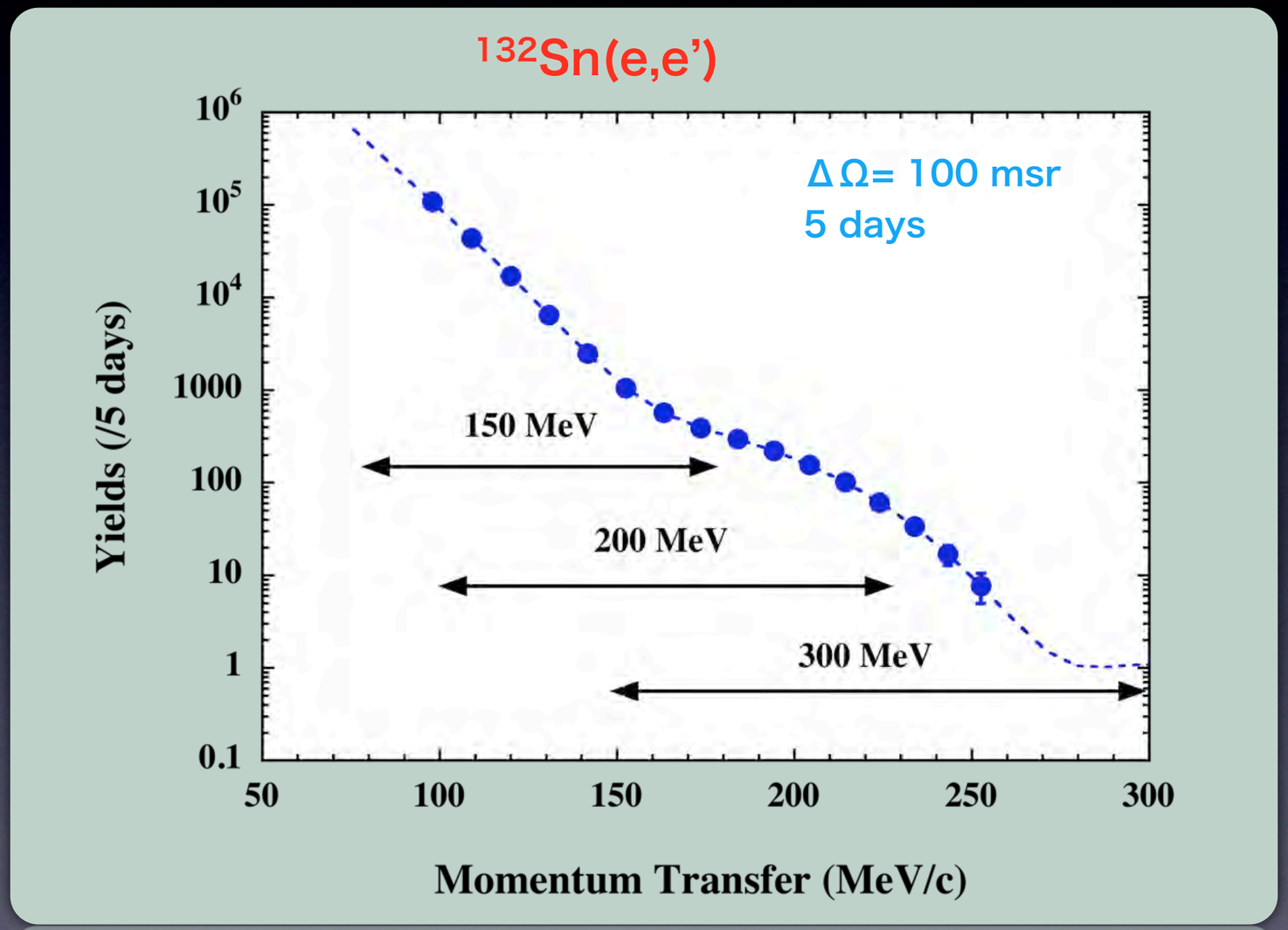
An example : Sn isotopes

^{132}Sn (Z=50, N=82) 40s



Luminosity ➡ A key for e-RI scattering exp.

$L = 10^{27}$ /cm^2/s



better than a few % accuracy of diff. radius and diffuseness

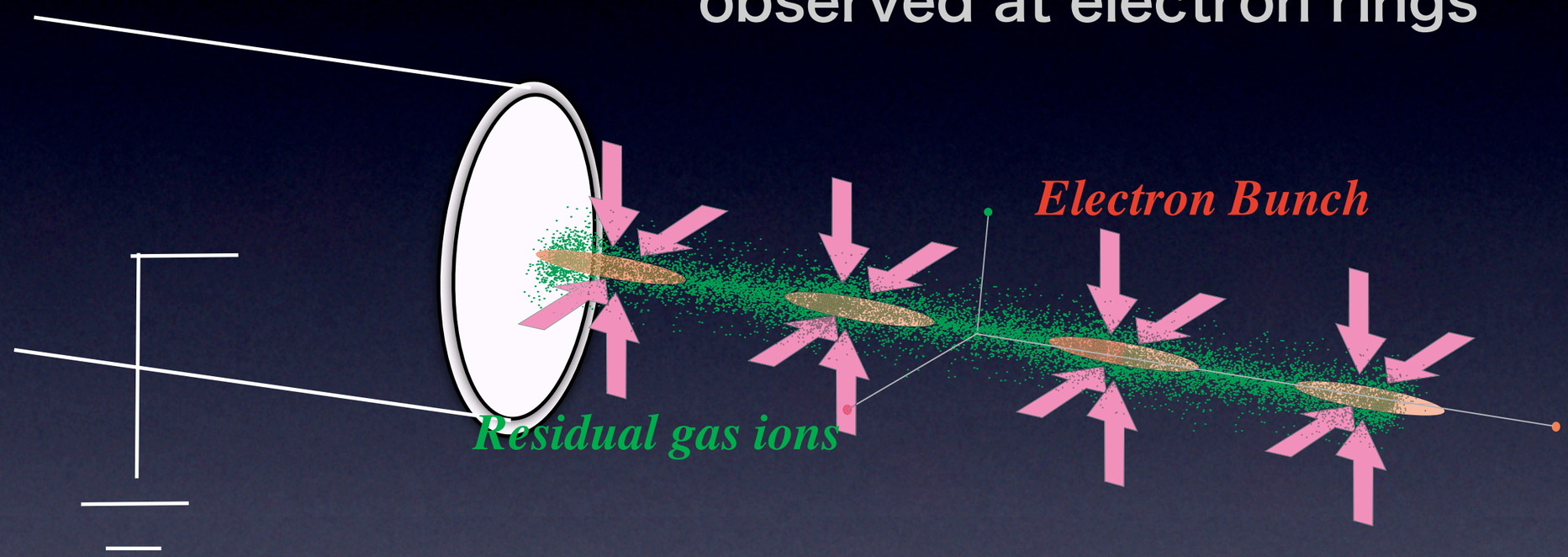
SCRIT as a novel way for e-RI scattering

(Self-Confining RI Target)

NIM A532, 216 (2004)
M. Wakasugi, T. Suda and Y. Yano

problematic "Ion trapping" phenomena

observed at electron rings



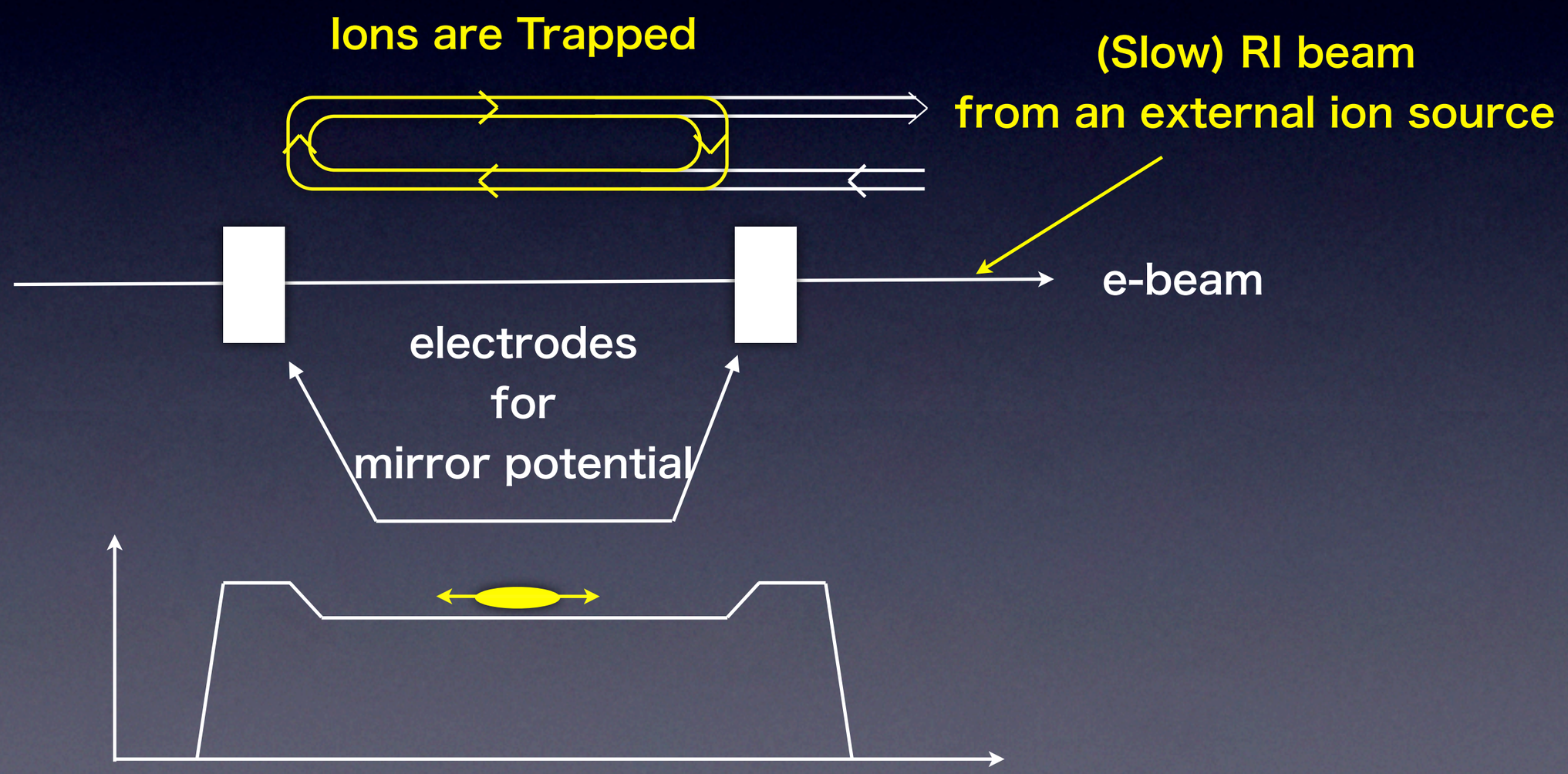
ionized residual gases by electrons are
trapped by electron beam itself.

the trapped ions kick out electrons ---> shorter beam lifetime

electron scattering !!

SCRIT as an RI target for electron scattering

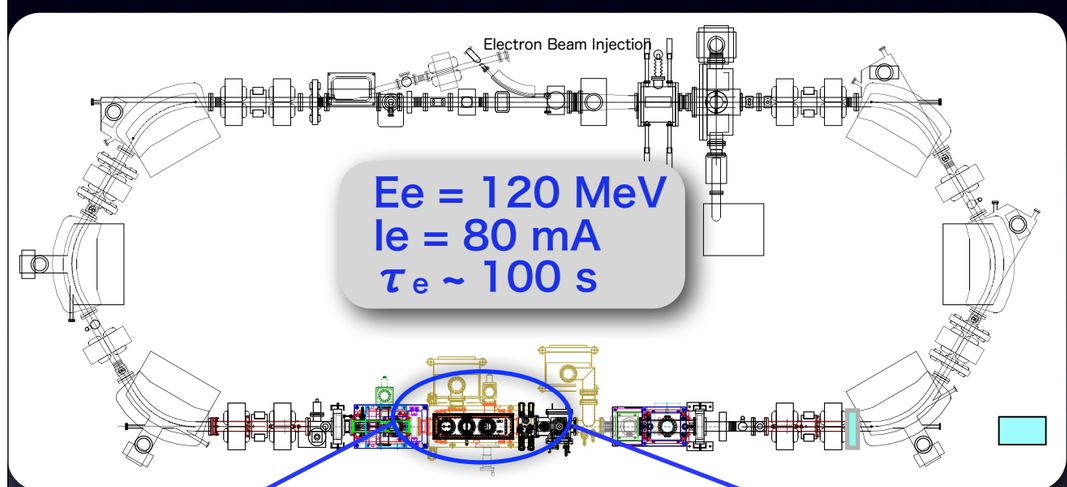
transverse : ion trapping
longitudinal : mirror potential

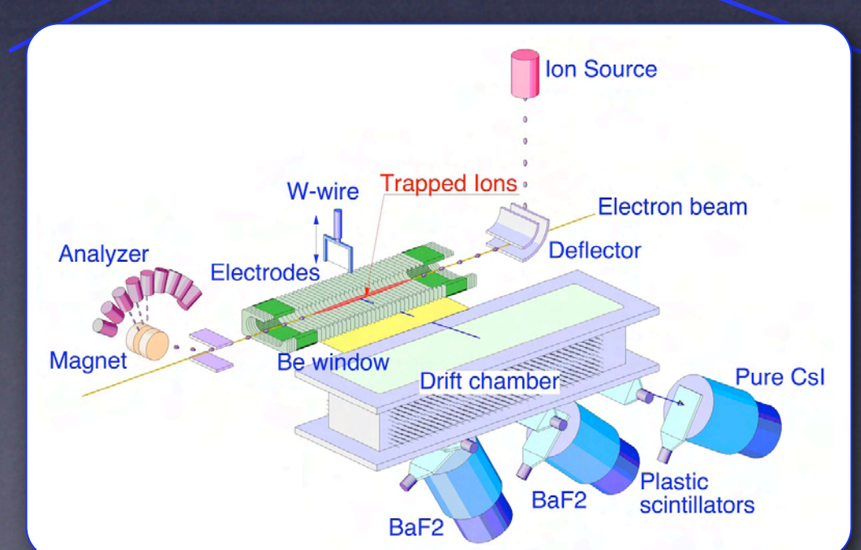


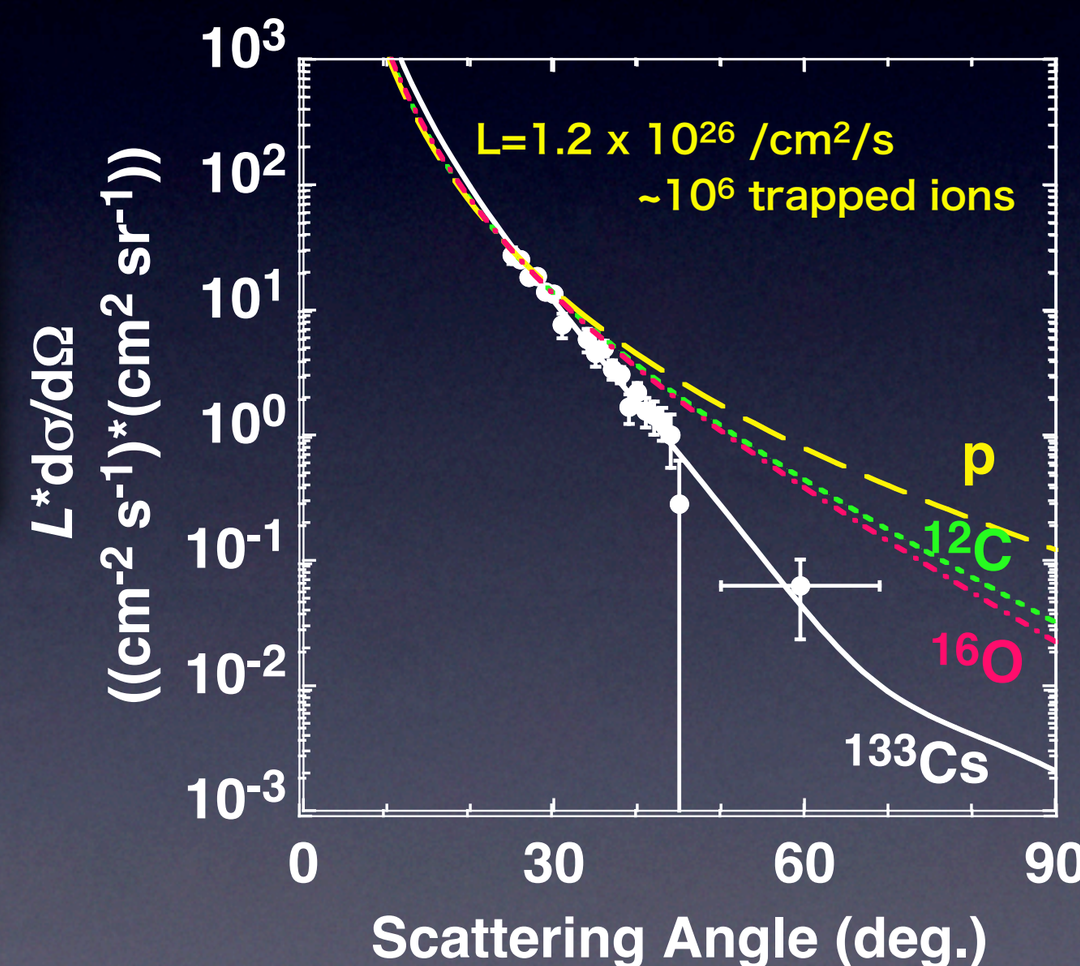
A proof-of-principle experiment of SCRIT (2004-2008)

a real electron scattering experiment using SCRIT mimicking rarely-produced short-lived nuclei

$N_{ions} \sim 10^6$ $t_{trapping} \sim 50$ ms







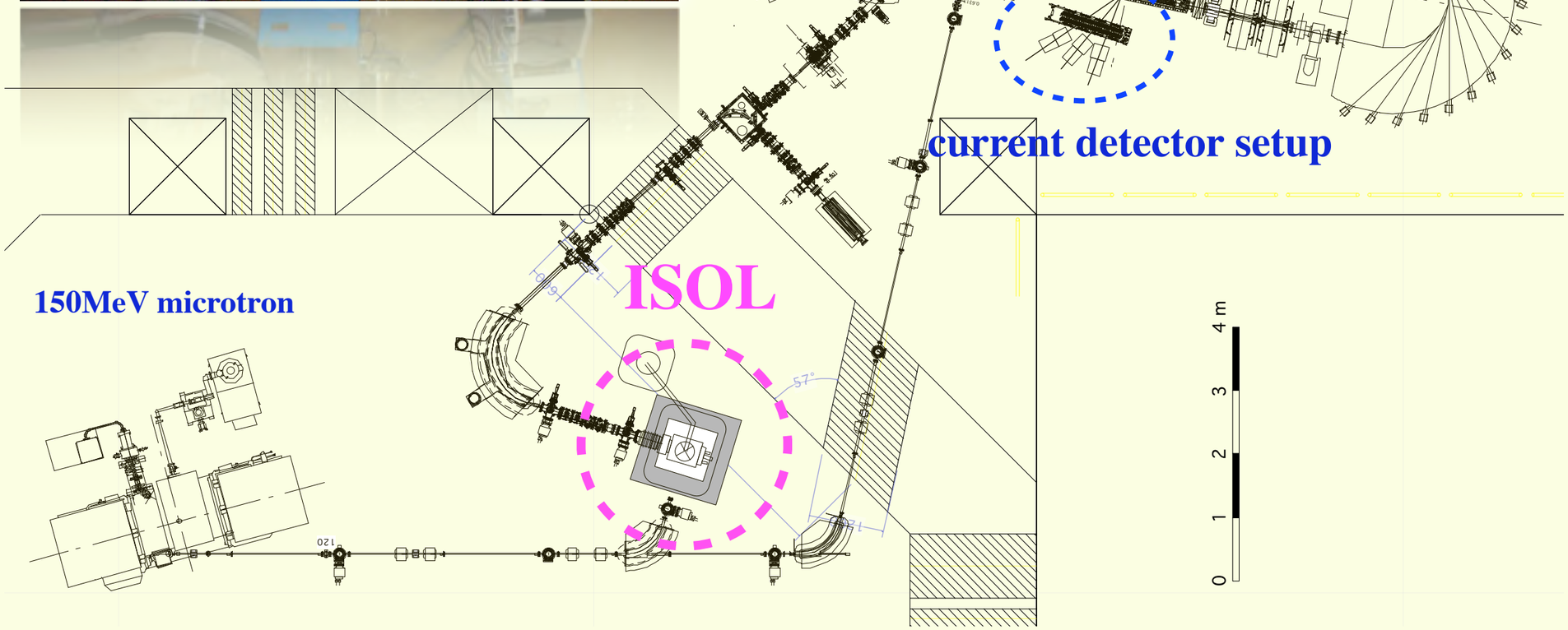
PRL 100 (2008) 164801
PRL 102 (2009) 102501

The SCRIT electron scattering facility

for rarely-produced short-lived exotic nuclei

under construction at RIKEN RI Beam Factory, JAPAN

Electron scattering facility at RIBF



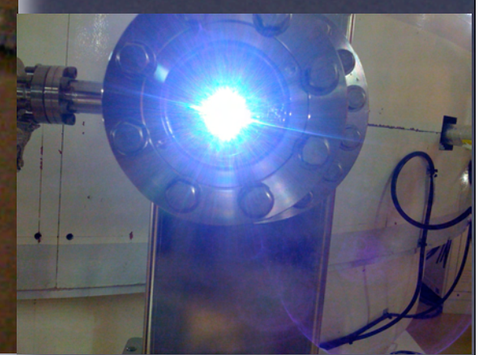
Electron storage ring (+150 MeV microtron)

Ee = 150 - 700 MeV

Ie ≥ 300 mA

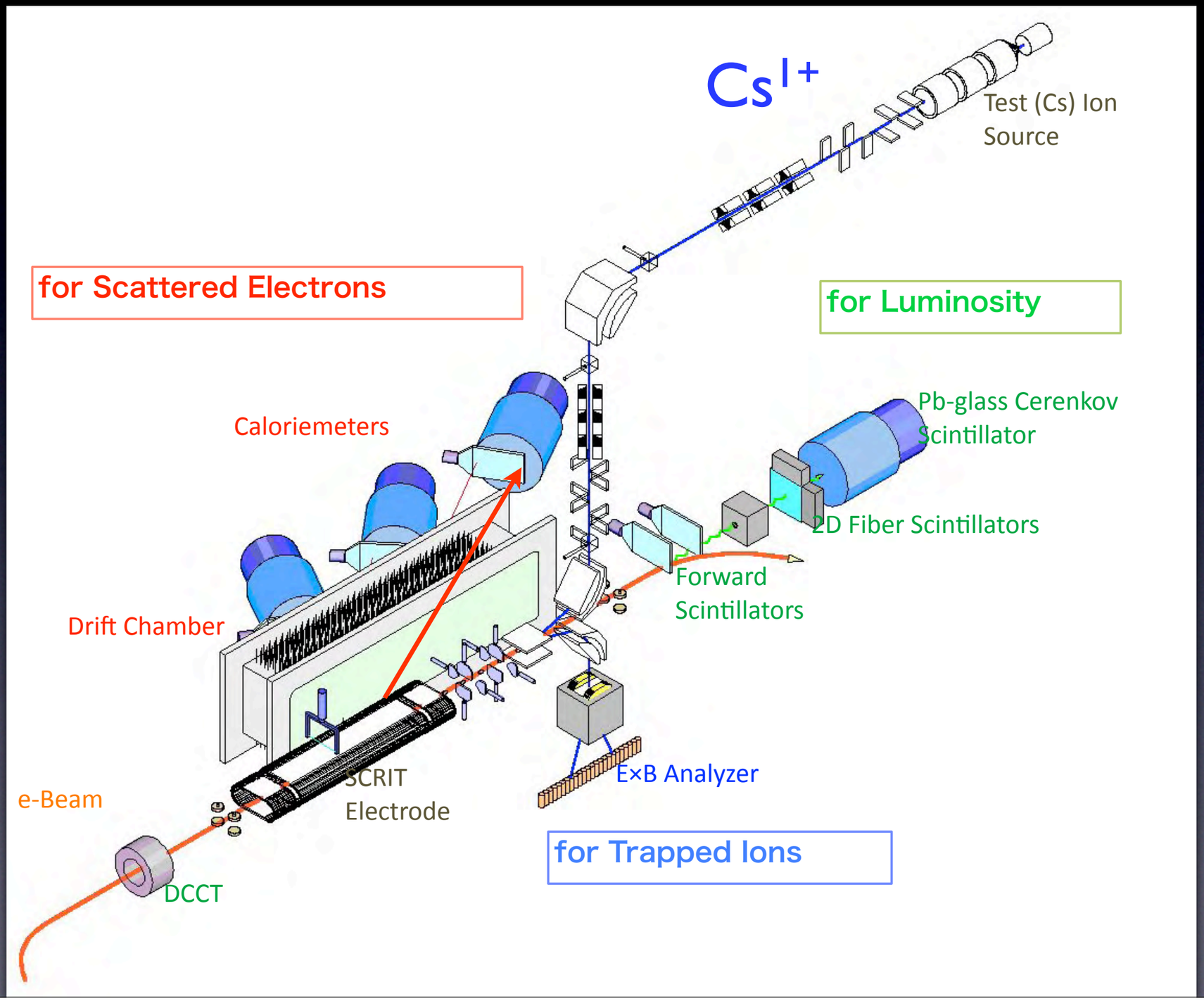
τ_{beam} ~ ~2 h@300mA as of today

First SR light
(Feb.8, 2010)

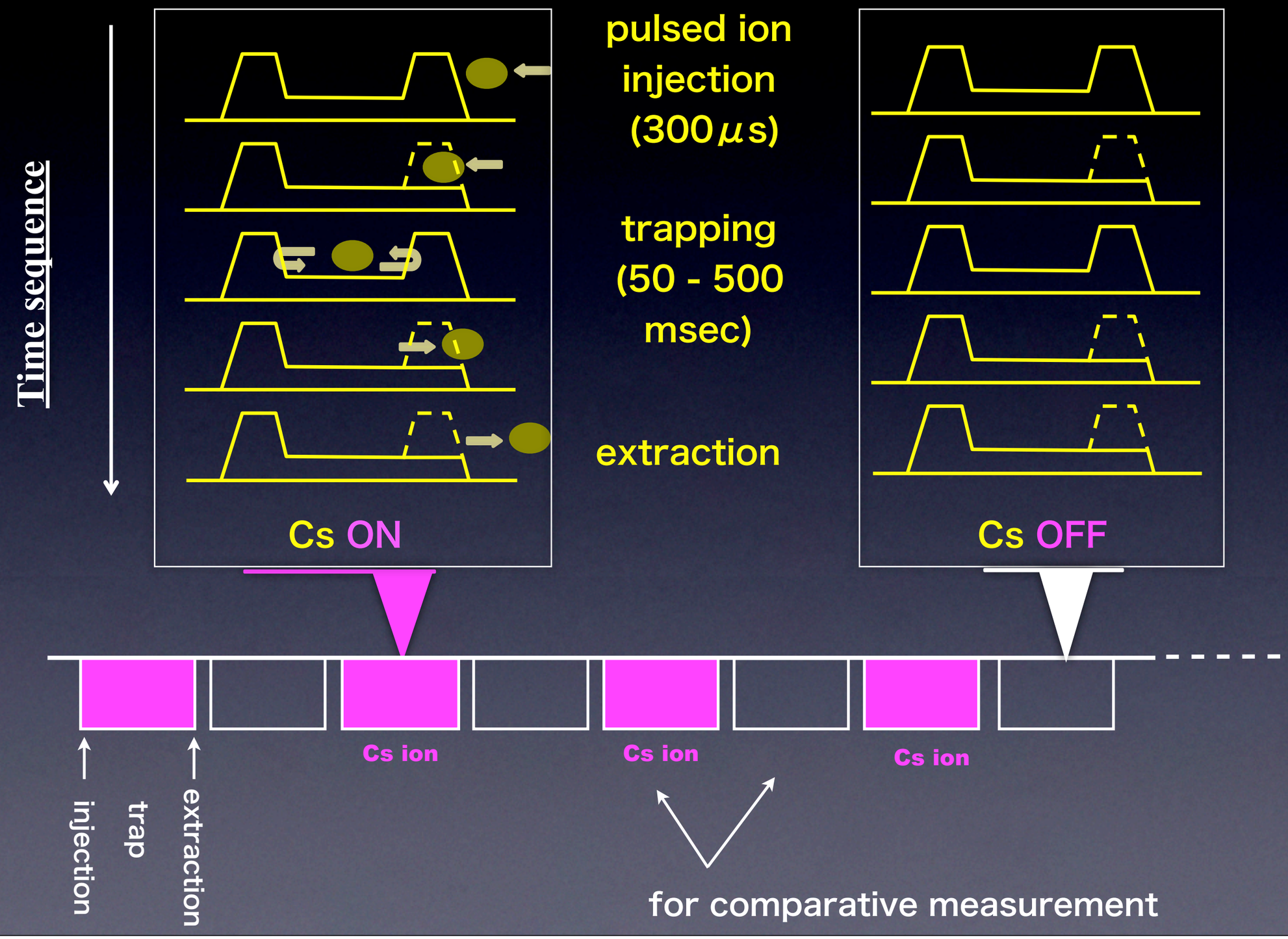


R&D using (stable) Cs ions

achievable luminosity and required number of ions



Study of trapping of externally injected (stable) ^{133}Cs ions

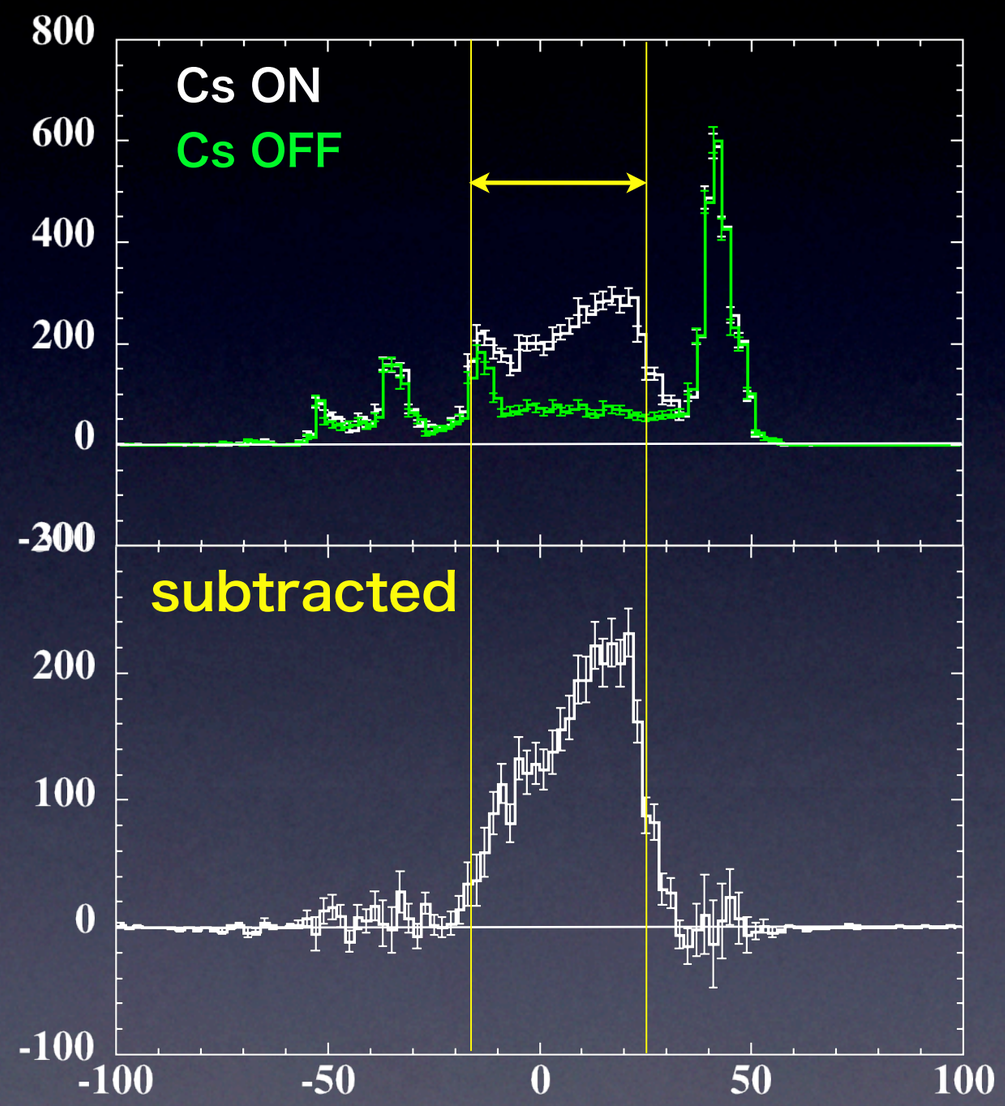


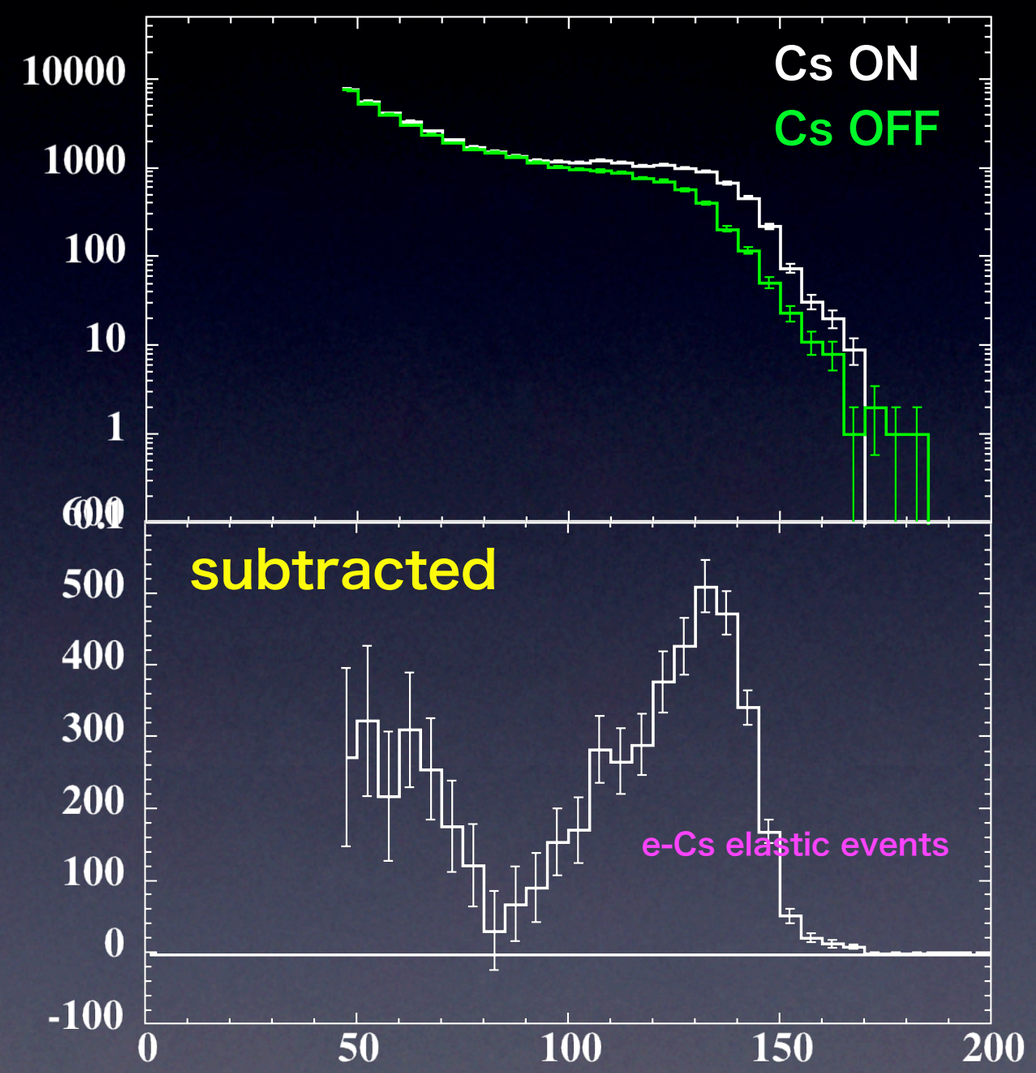
scattered electrons from trapped Cs ions

Ee = 150 MeV

Cs trap region : 40 cm

2011. Oct.



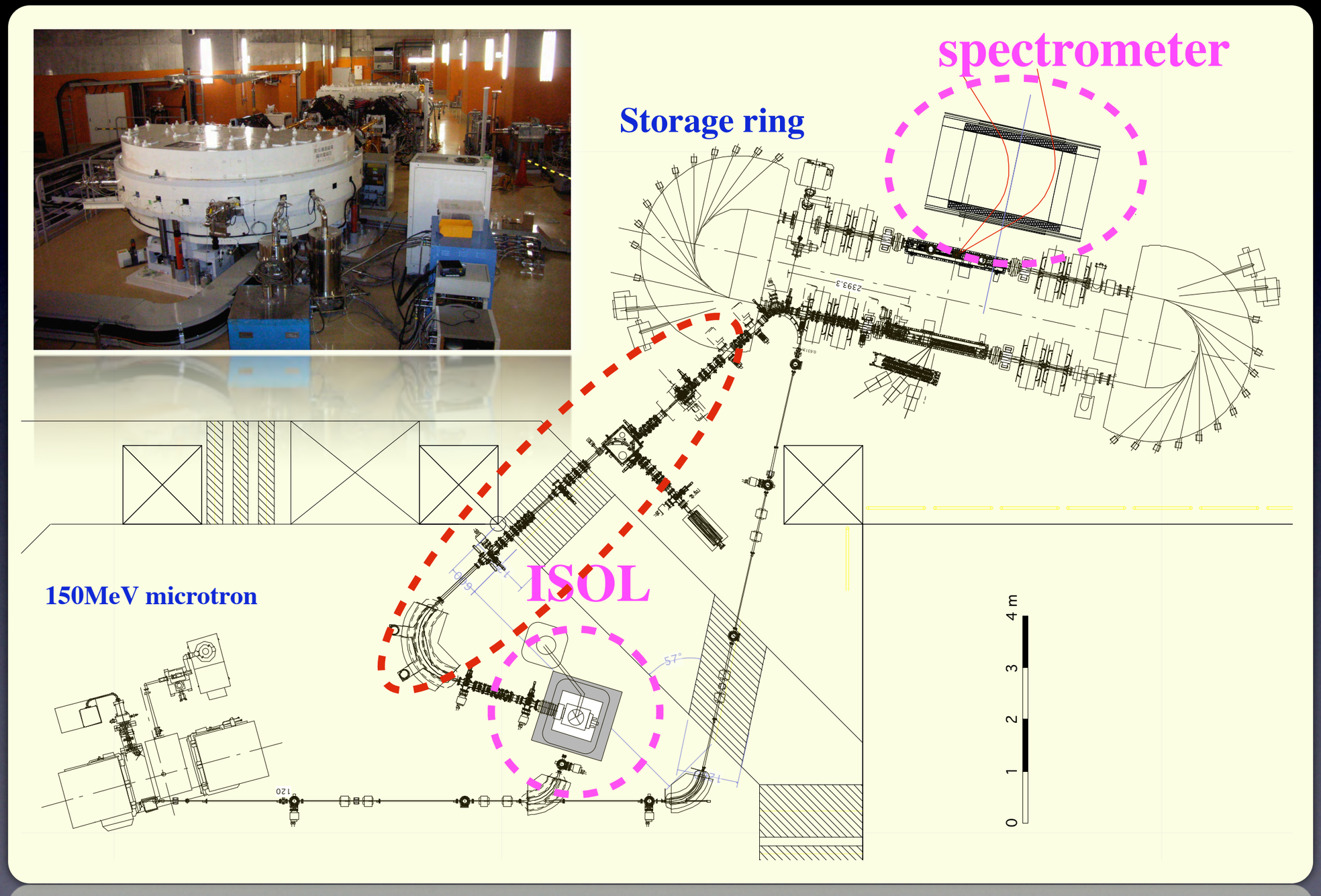


Vertex (cm)

Ee (MeV)

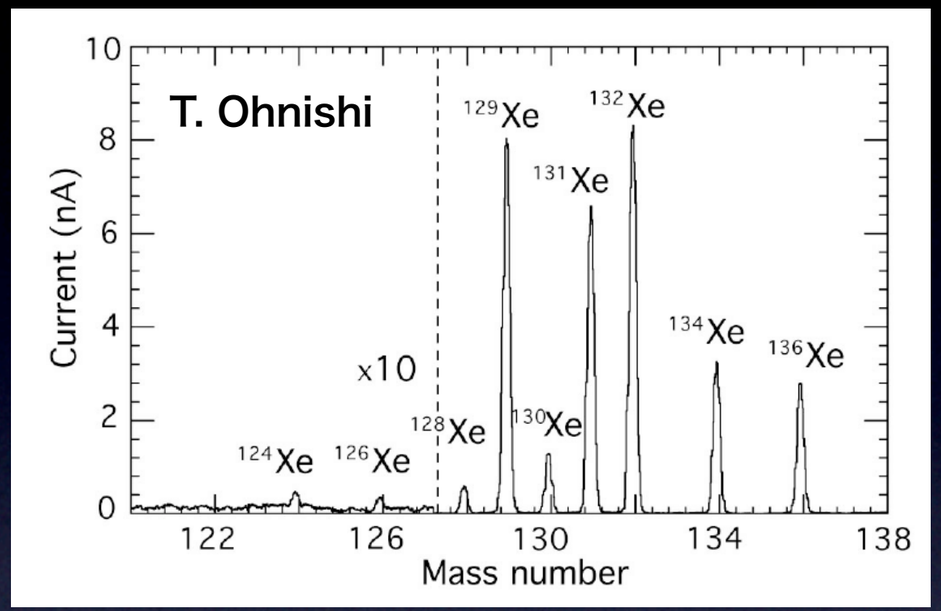
L ~ 10^{27} /cm^2/s with N_{Cs} ~10^7

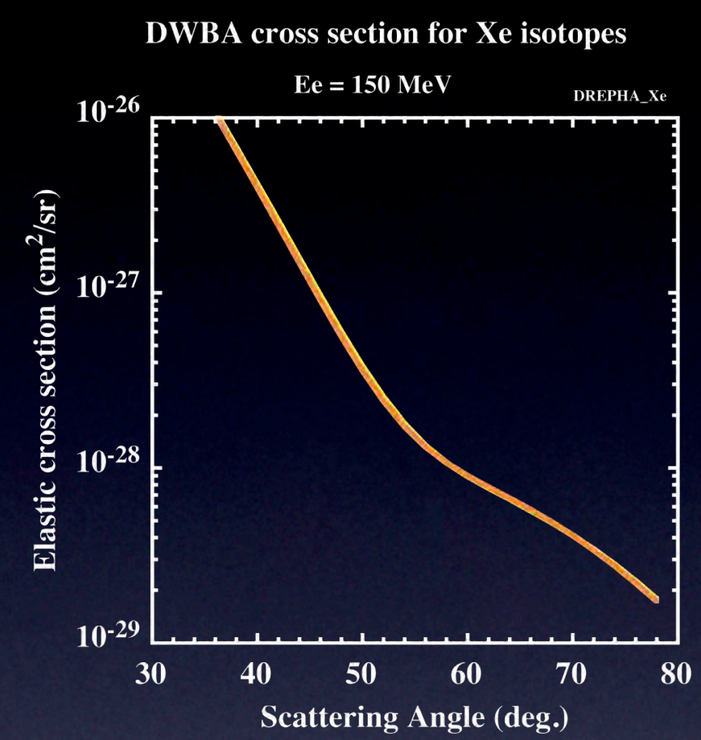
Electron scattering facility at RIBF

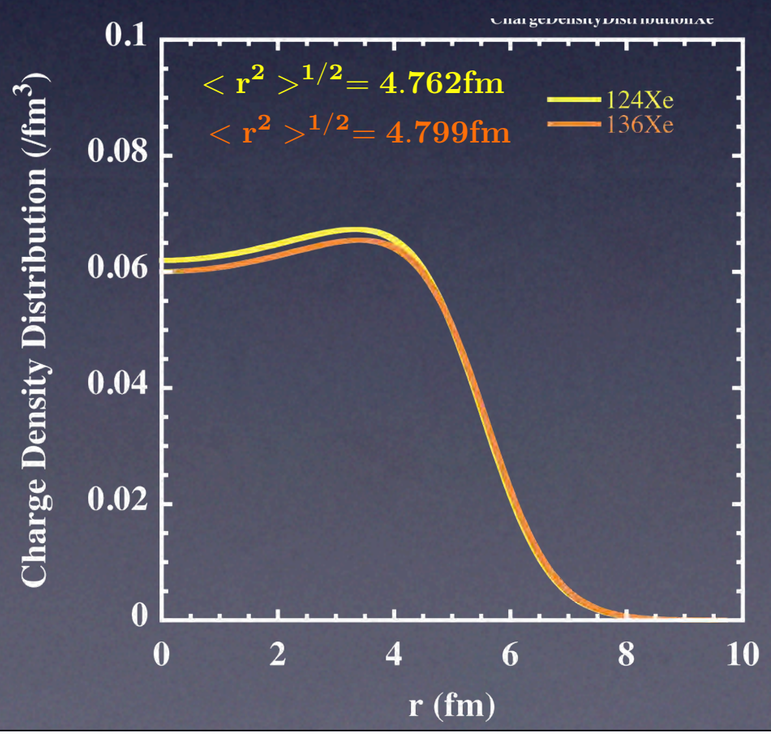


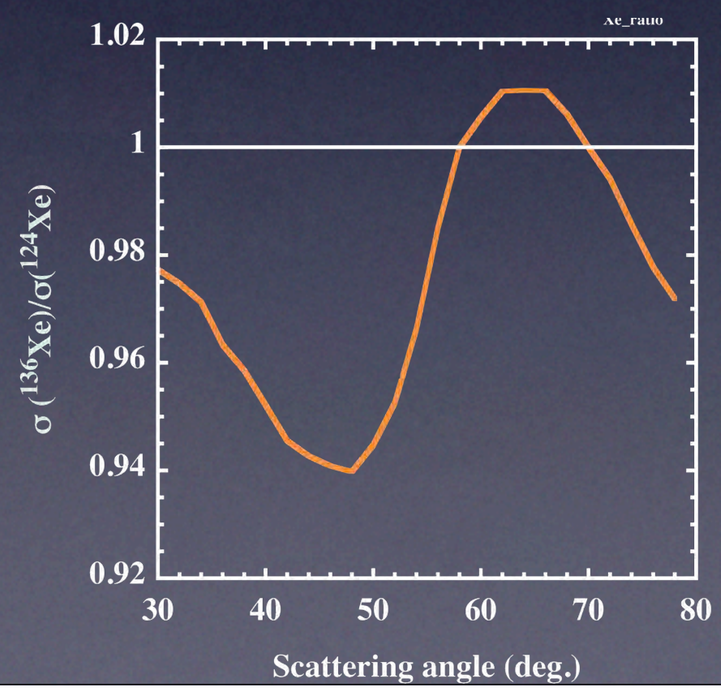
Next R&D including the new ion beam line (2012. April ~)

Xe isotopes (^{124}Xe - ^{136}Xe)







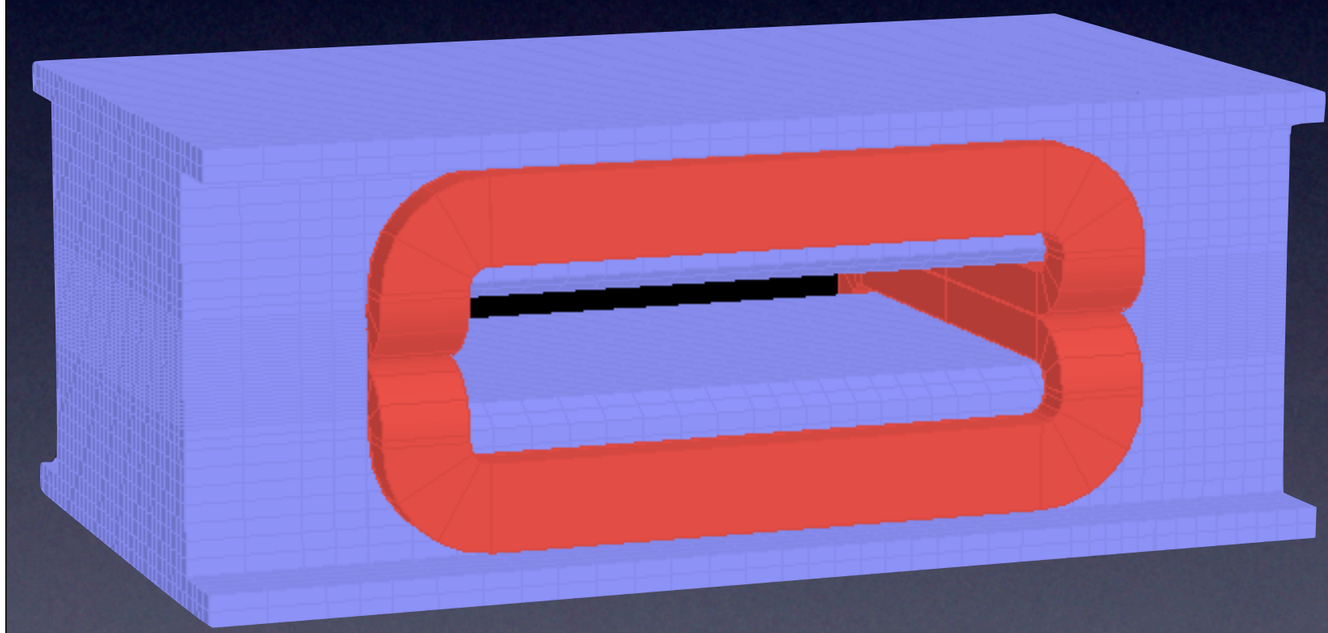


electron spectrometer

identification of elastic scattering
Low luminosity
long target region (40cm)
accurate angular distribution

→

high resolution
large acceptance
long-target acceptance
wide θ coverage



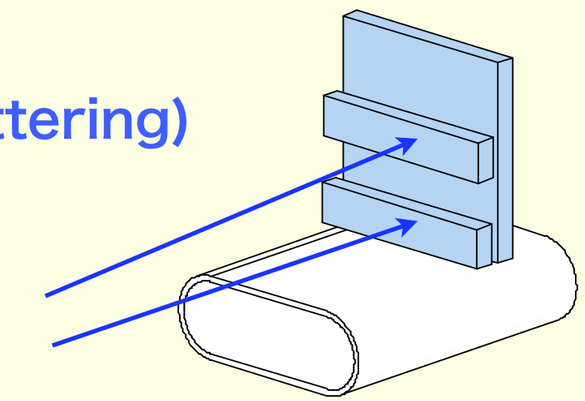
- weight ~ 50 tons
- Bmax = 0.8 T
- $\Delta p/p \leq 10^{-3}$ (ΔE<300keV@300MeV
- $\Delta\theta$ = 30° (45±15°)
  $\Delta\Omega$~ 90 msr
  1700 (w) x 300 (h) x 1400 (l)

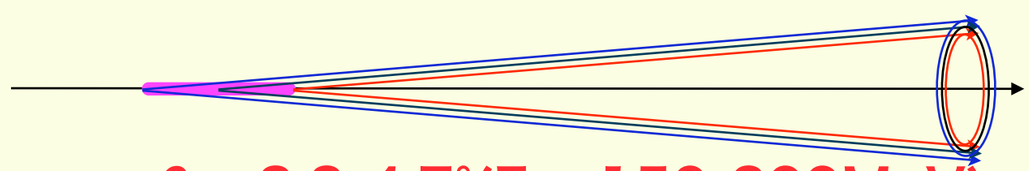
- field leakage at e-beam : a few G
- tracking by sets of drift chambers

under construction
commissioning from 2012.Dec.

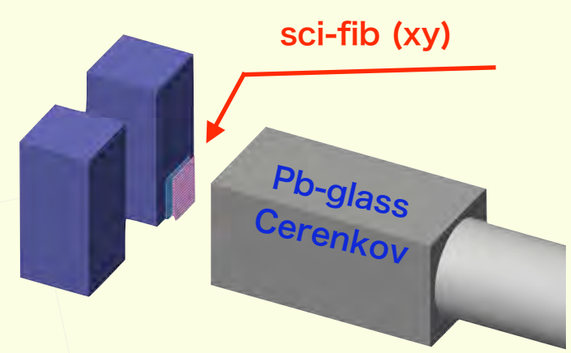
Luminosity monitoring

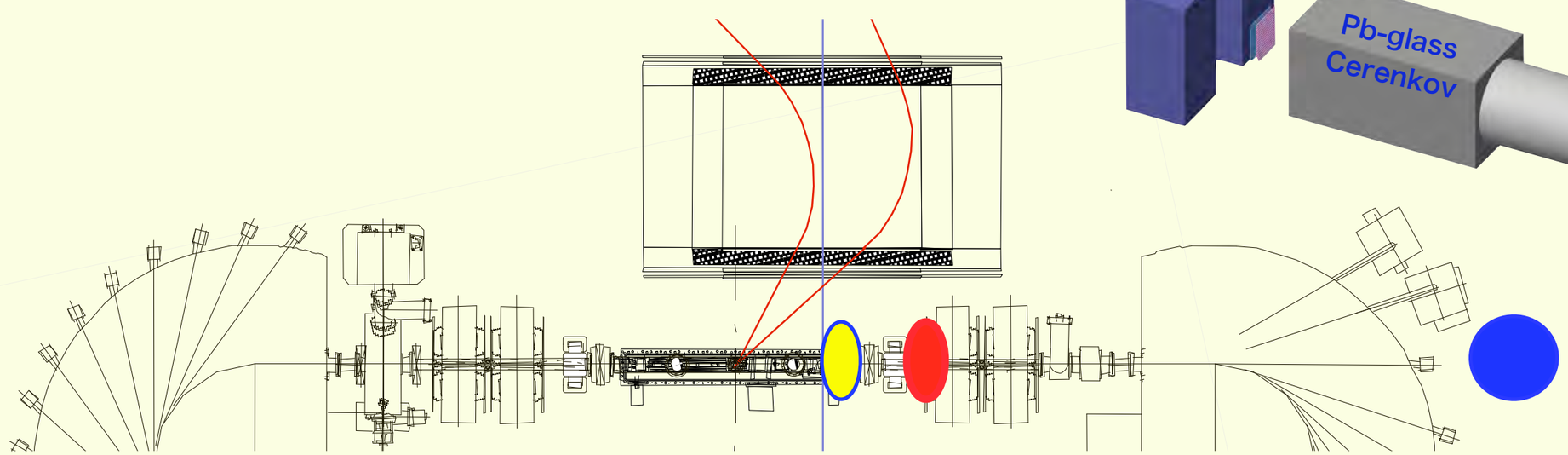
- Bremsstrahlung
- beam loss monitor (ultra forward scattering)
- Moeller scattering





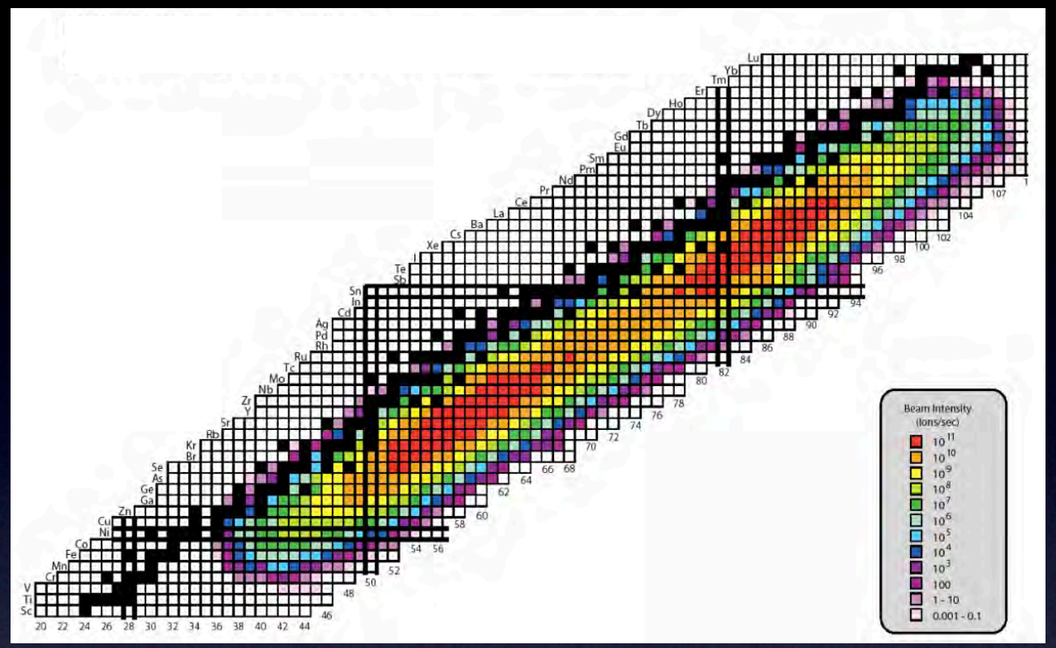
θ_e=3.3-4.7°(Ee=150-300MeV)

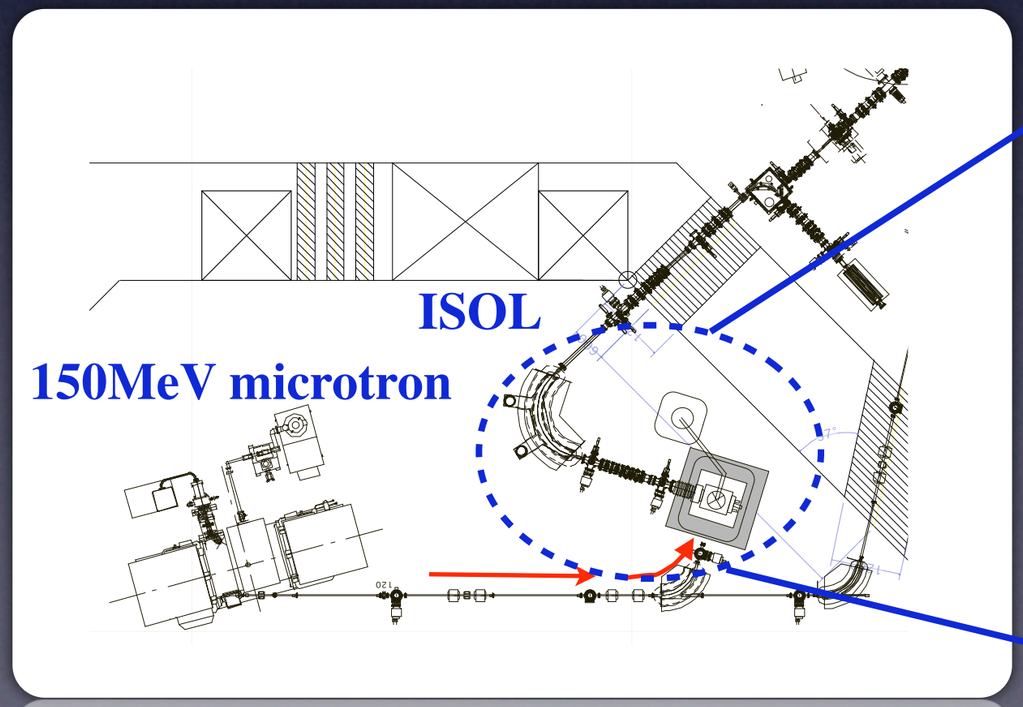


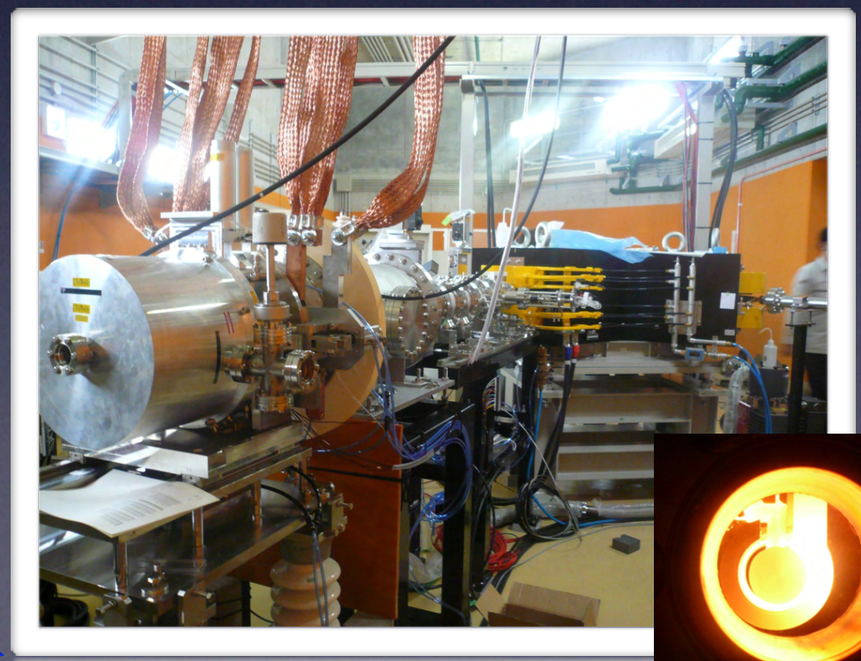


ISOL

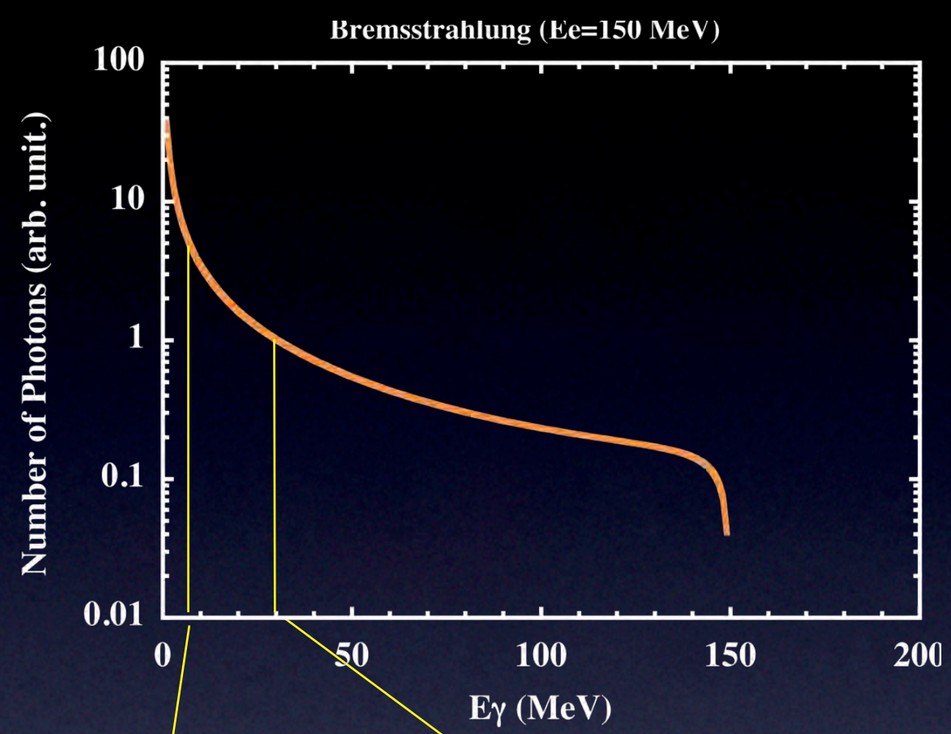
RI production
by electro-(photo-) fission
of ^{238}U

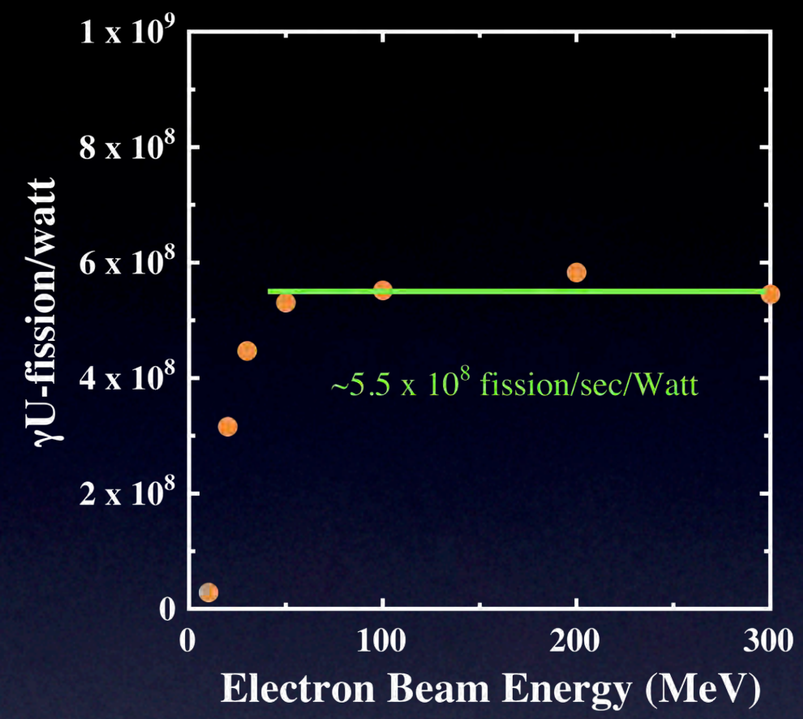


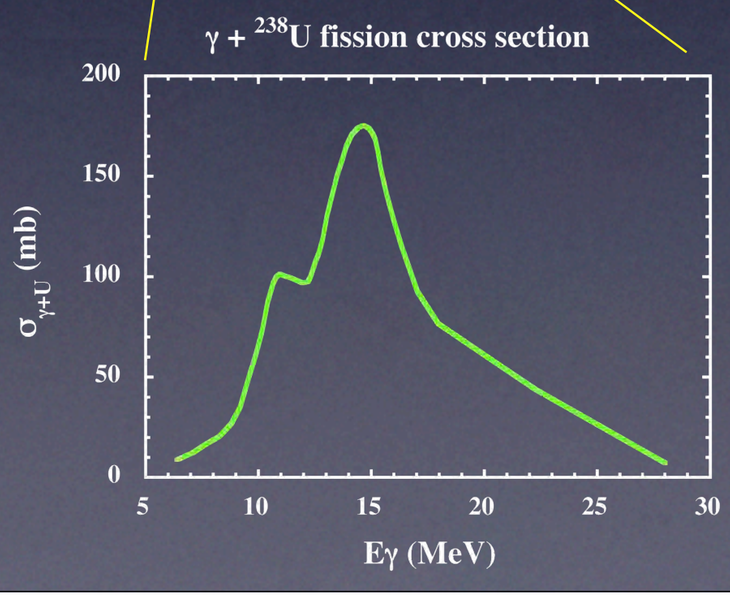


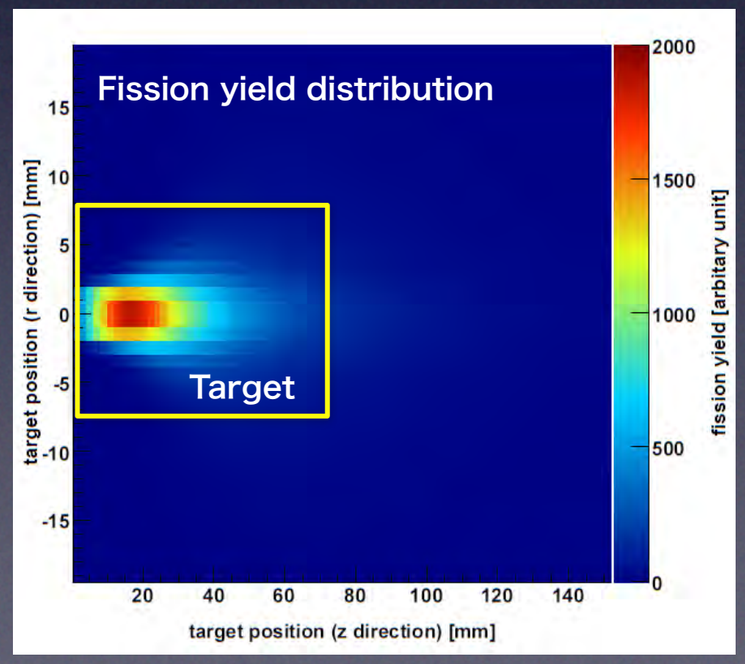


γU fission reaction

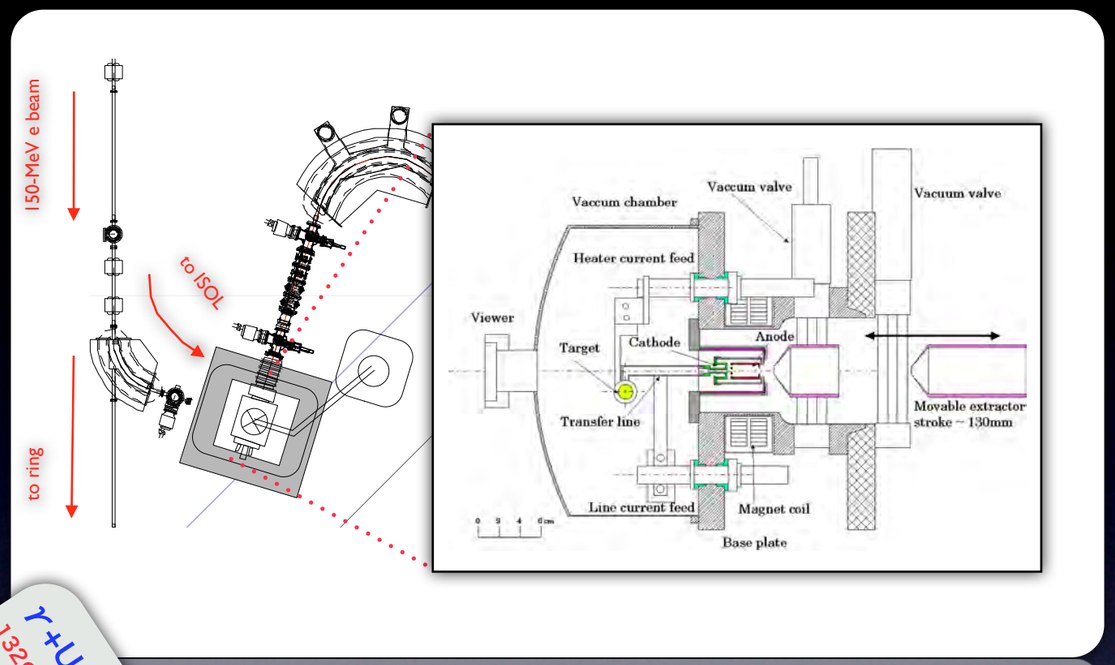








an ISOL system for SCRIT based on γU fission reaction

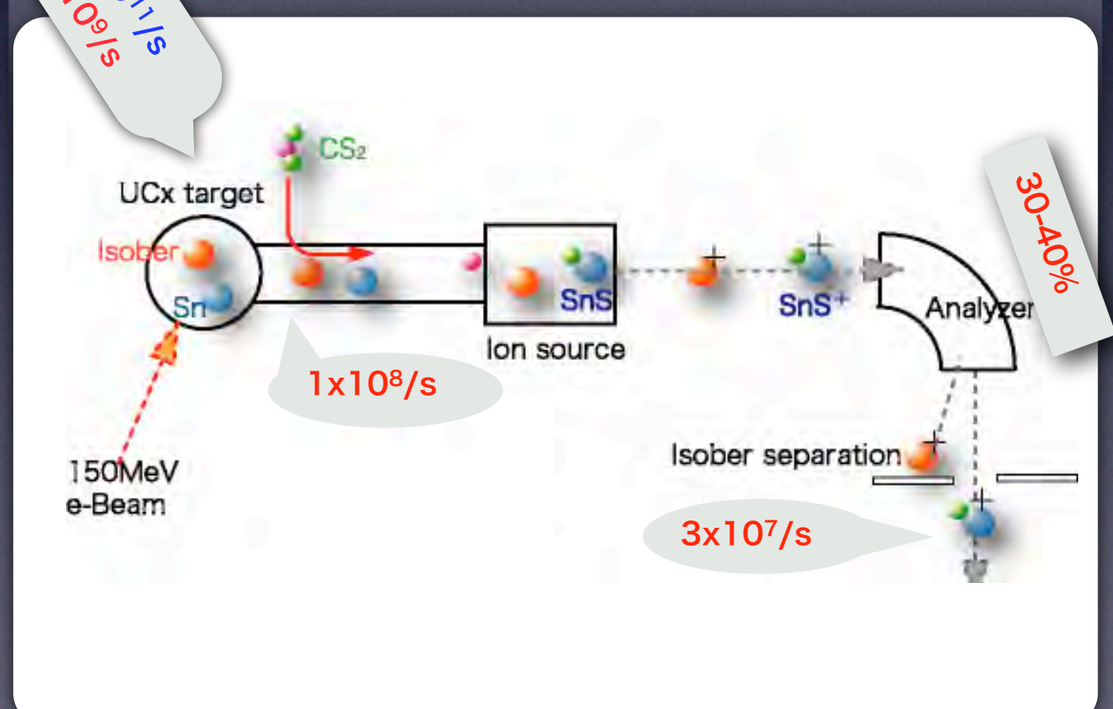


design based on construction/operation experience of JAERI-ISOL (S. Ichikawa)

- electron beam : 150 MeV/1.6 kW
- UC_x : ϕ15 mm, L 70mm (^{238}U ~24g)
- Yield : 2×10^{11} fission/s => ~2×10^{9} ^{132}Sn/s
- 1×10^{8} ^{132}Sn/s is extracted

  extraction efficiency : 6.5 % (JAERI)

γ+U 2×10^{11}/s
^{132}Sn 2×10^{9}/s



- Element separation

  molecular-ion SnS^+ (ORNL ...)
- Isobar separation

  purity better than 99 % is expected

Summary & Outlook

- a novel way, SCRIT, for electron scattering for short-lived nuclei
- electron scattering facility is under construction at RIKEN RIBF
  - ~10^{27} /cm^2/s achieved with $10^{6\text{-}7}$ trapped Cs ions
- ISOL (e(γ)+U) is under construction
  - SLOWRI / BigRIPS in future
- first e-RI scattering experiment in 2013