Structure Studies of Unstable Nuclei by Electron Scattering

Toshimi Suda
RIKEN, JAPAN

1. Electron scattering and nuclear structure
2. a novel RI trap for electron scattering experiment
   SCRIT (Self-Confining RI Target)
3. R&D studies
4. Summary

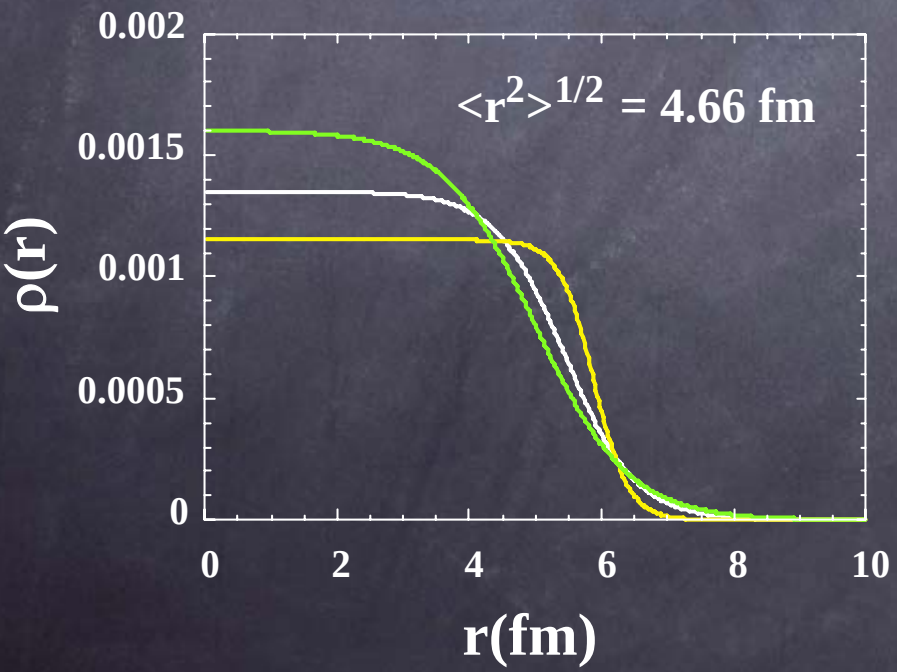
SCRIT collaboration:
RIKEN : T. Emoto, S. Ito, T. Koseki, S. Nakamura,
T. Ohnishi, H. Takeda, M. Wakasugi and Y. Yano
Rikkyo Univ. : K. Kurita, H. Morikawa

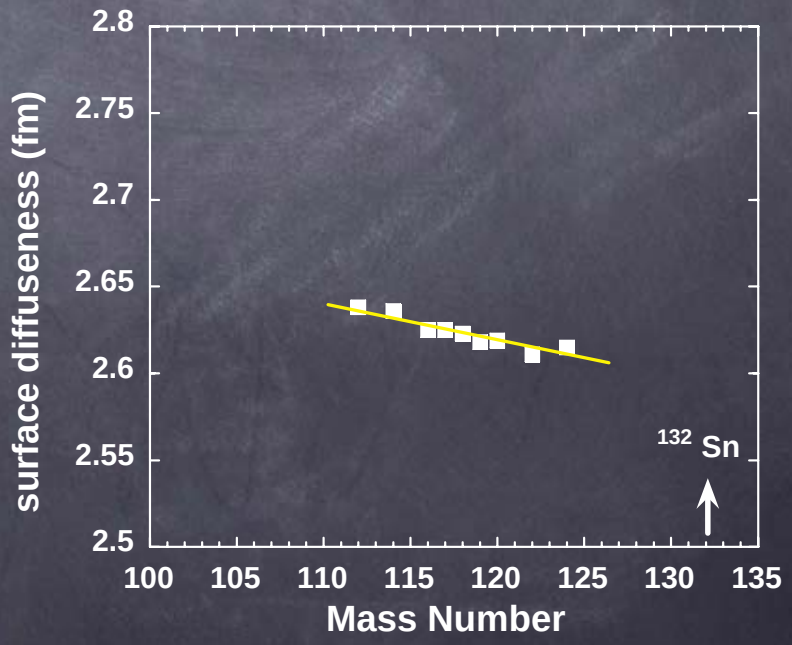
Size and Shape of short-lived nuclei

Fundamental quantities such as m, τ

Nuclear (rms) radius : interaction cross section
Charge (rms) radius : isotope shift

Nucleon distribution : hadron (proton) scattering
Charge distribution : electron scattering



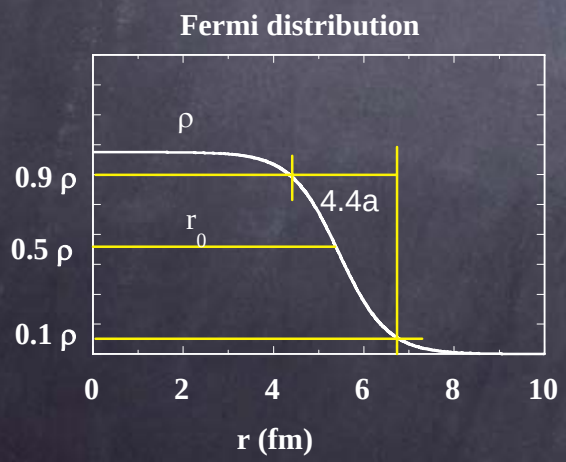


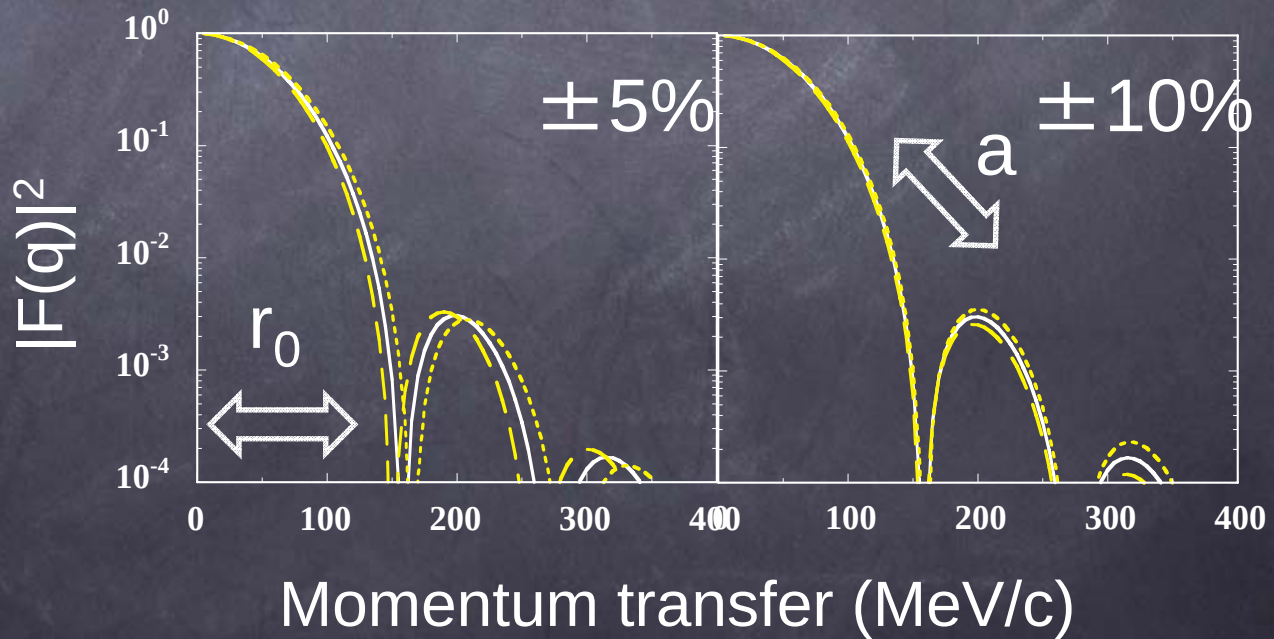
Electron Scattering from unstable nuclei

- Most precise probe for structure studies
- No electron scattering experiments from short-lived nuclei, due to lack of their target.

elastic scattering => charge form factor

Toy model





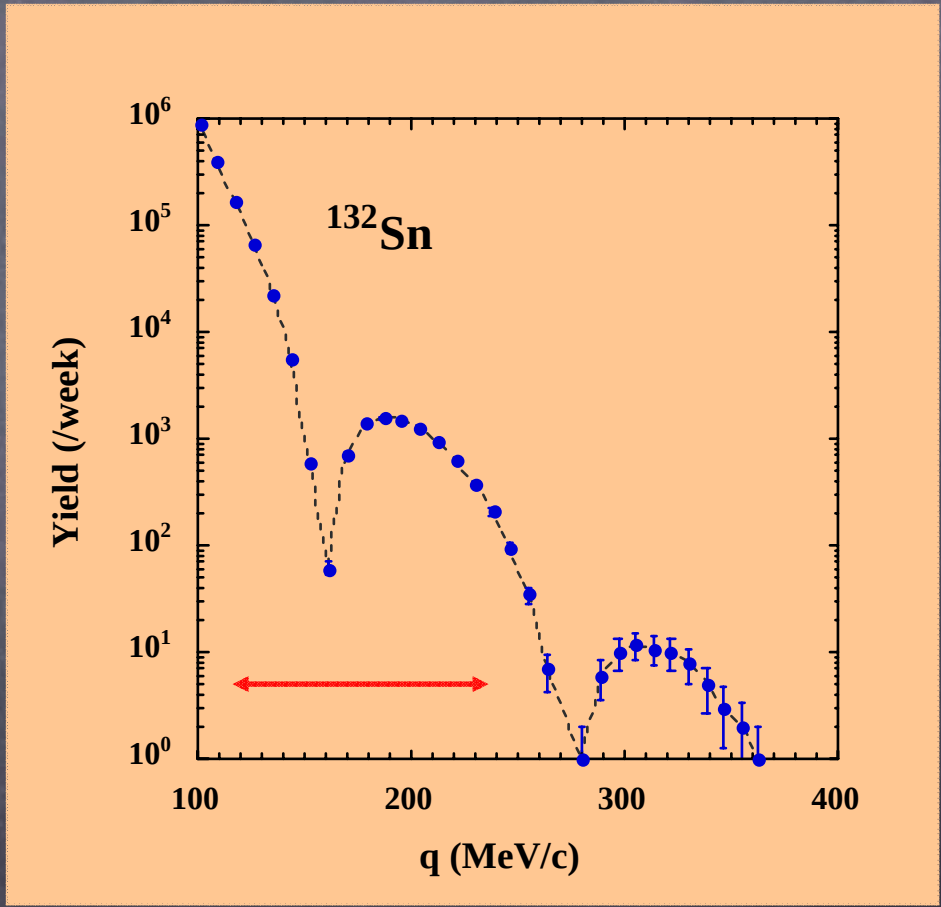
Form factor and required luminosity

Diffraction radius and surface diffuseness

At least the measurement must cover the first maximum of the form factor

high resolution spectrometer
$\Delta\Omega$~30 mSr

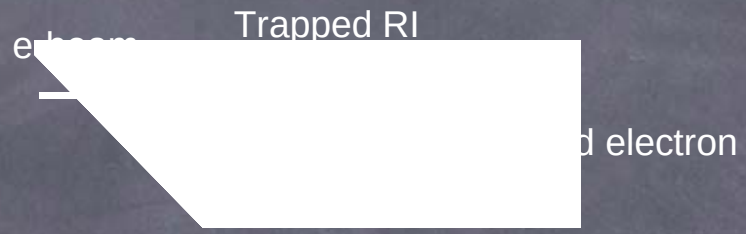
L ~ 10^{27} ~ 10^{28} /cm^2/s



How to realize eRI scattering ?

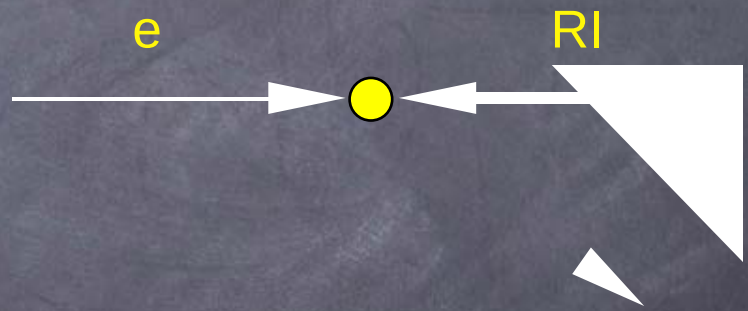
1.e-beam on “fixed” RI target

Ee ~ a few 100 MeV



2. Electron + RI collider (GSI project)

Ee ~ a few 100 MeV



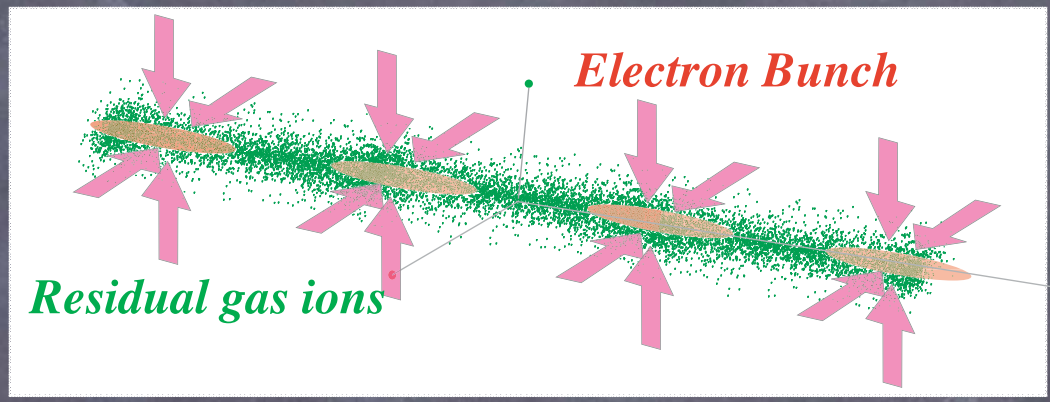
3. RI-beam on “fixed” electron target

(reltivistic) RI beam

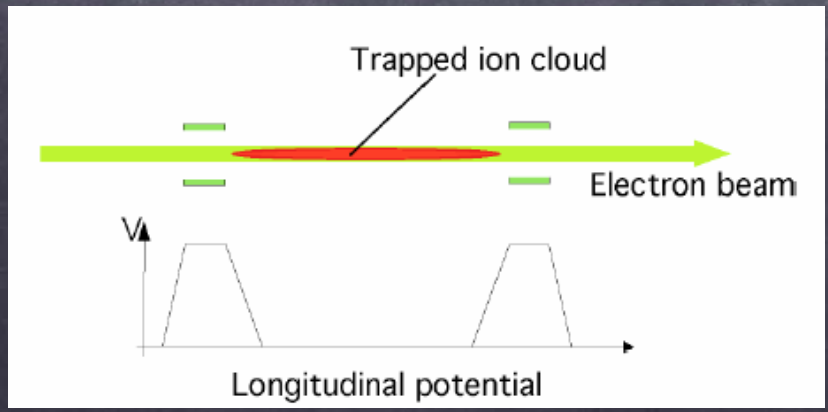
γ_{RI} ~ a few 100

A novel method for eRI scattering
SCRIT (Self-Confining RI Target)

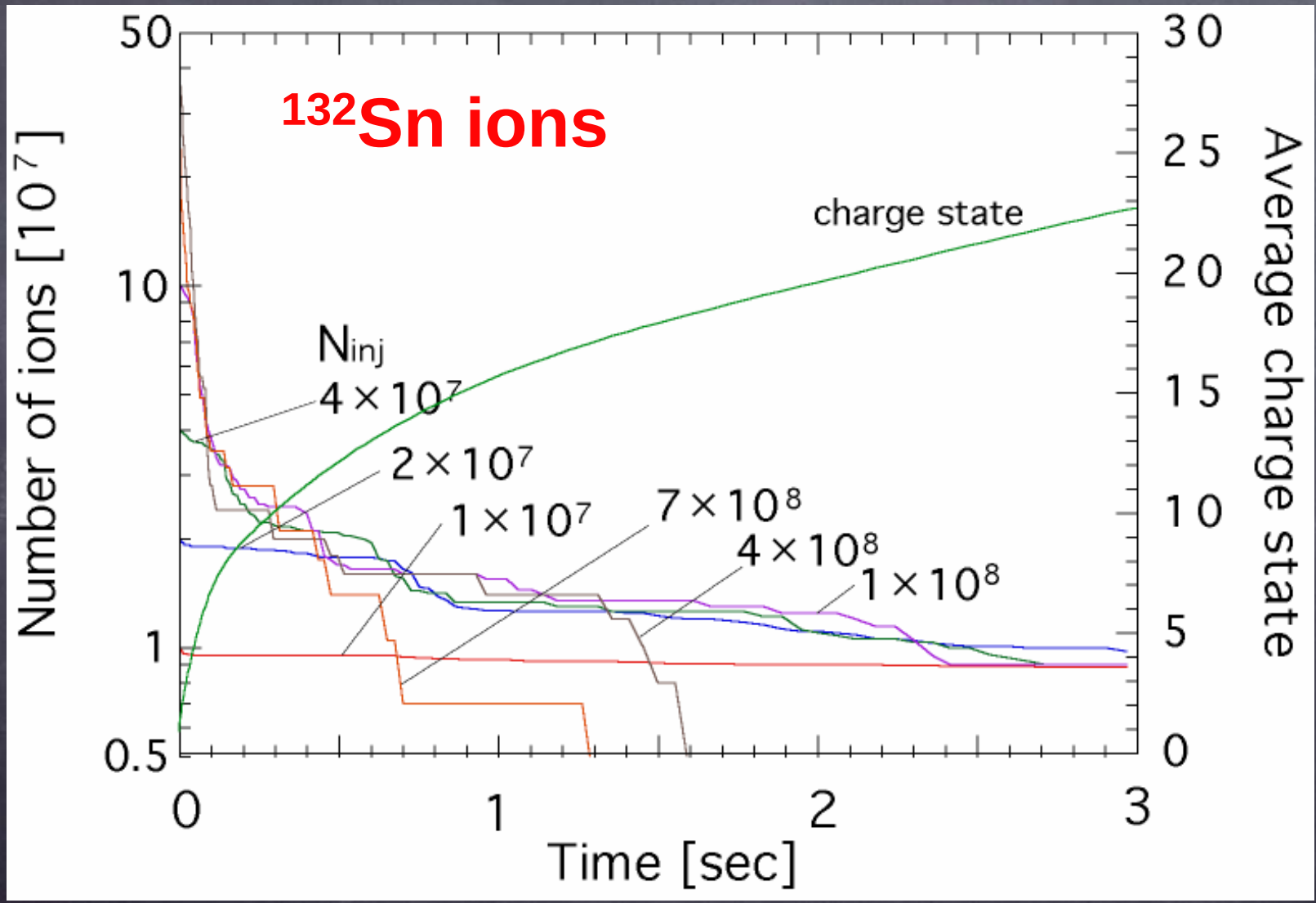
Ion trapping : a well-known phenomena at e-storage ring.
shorter beam life time, instability



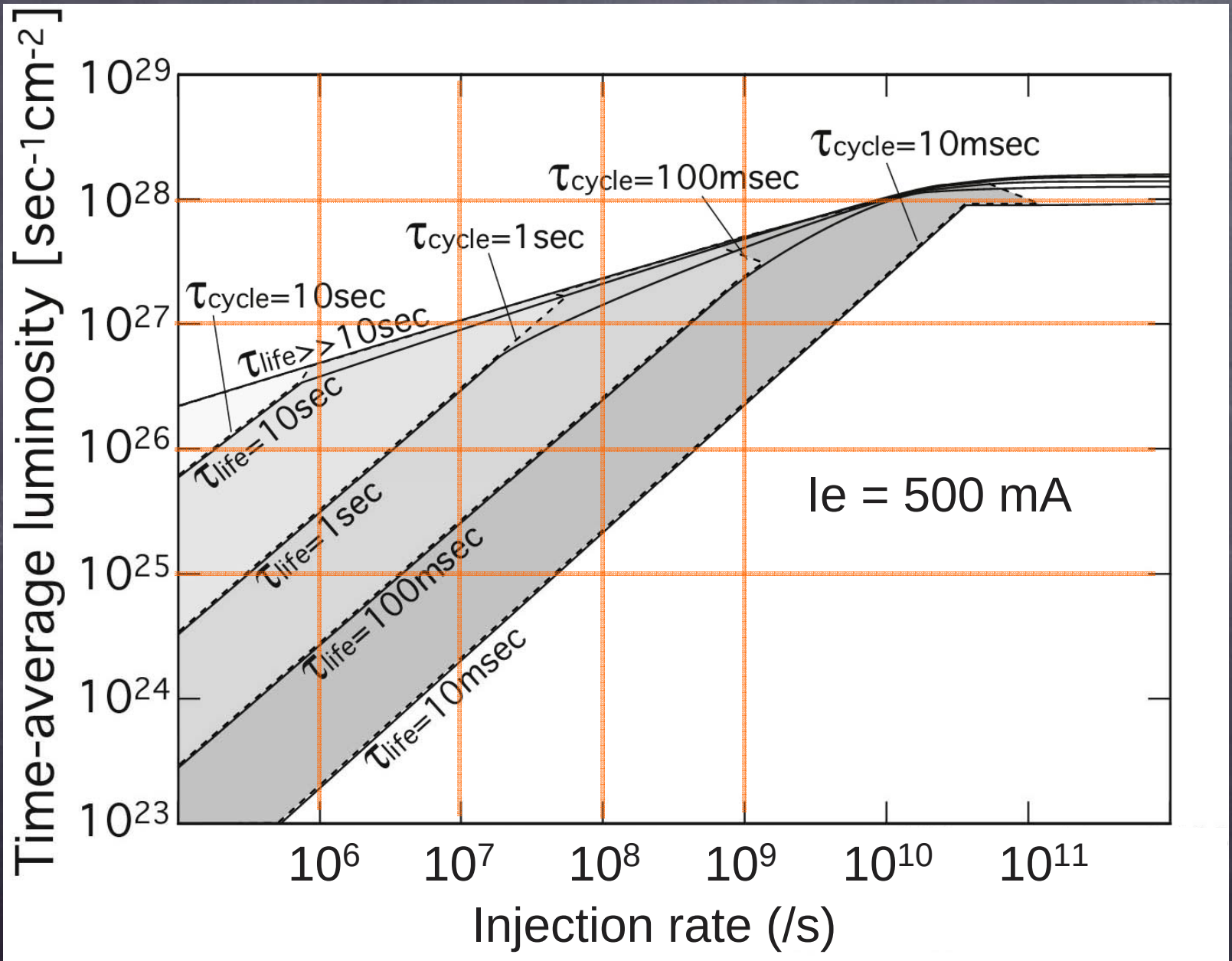
Ion trapping + mirror potential for longitudinal trapping
Spatially confined RI target



Numerical simulation



expected luminosity

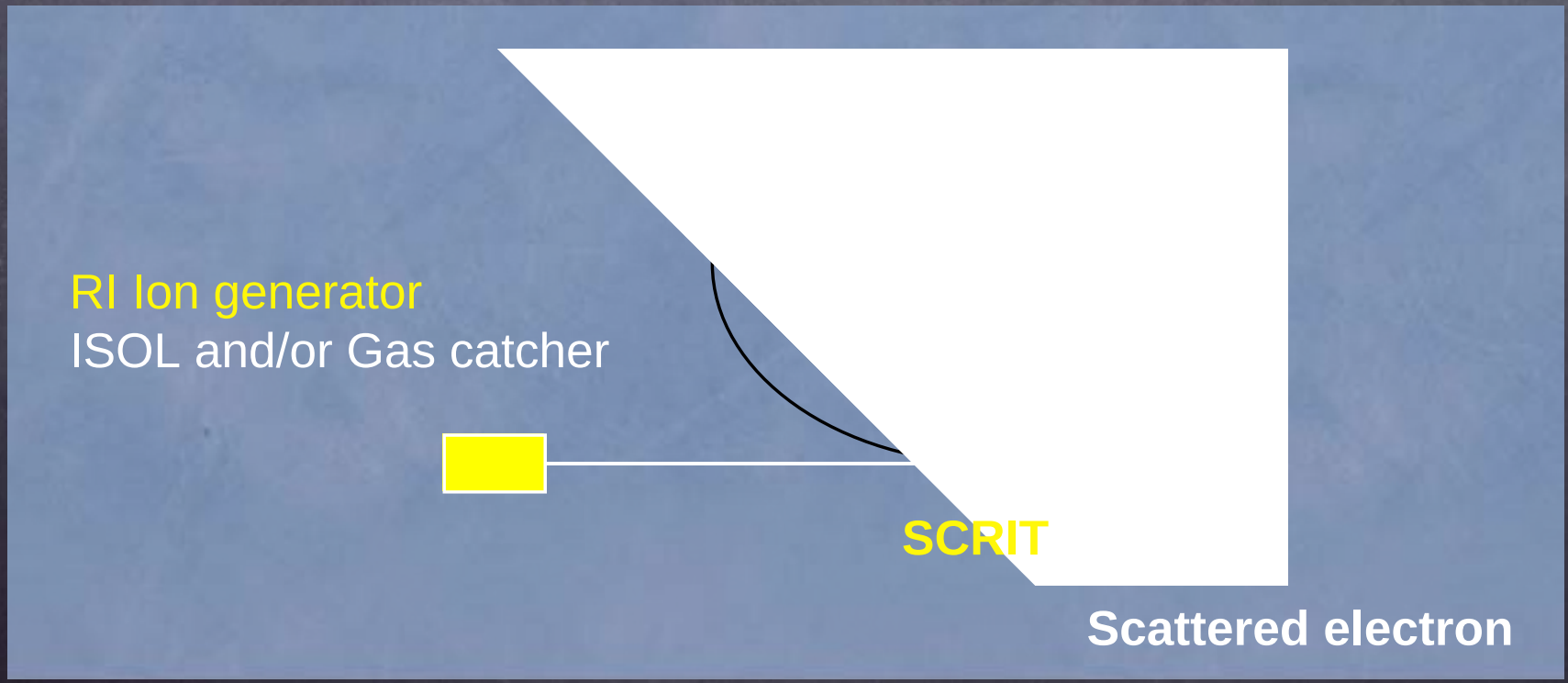


eRI facility based on the SCRIT concept

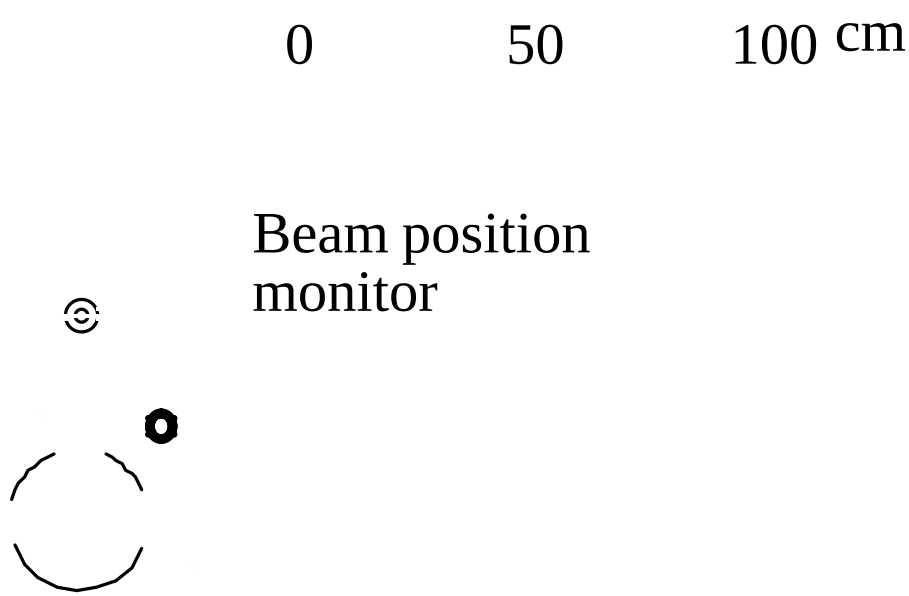
Electron storage ring

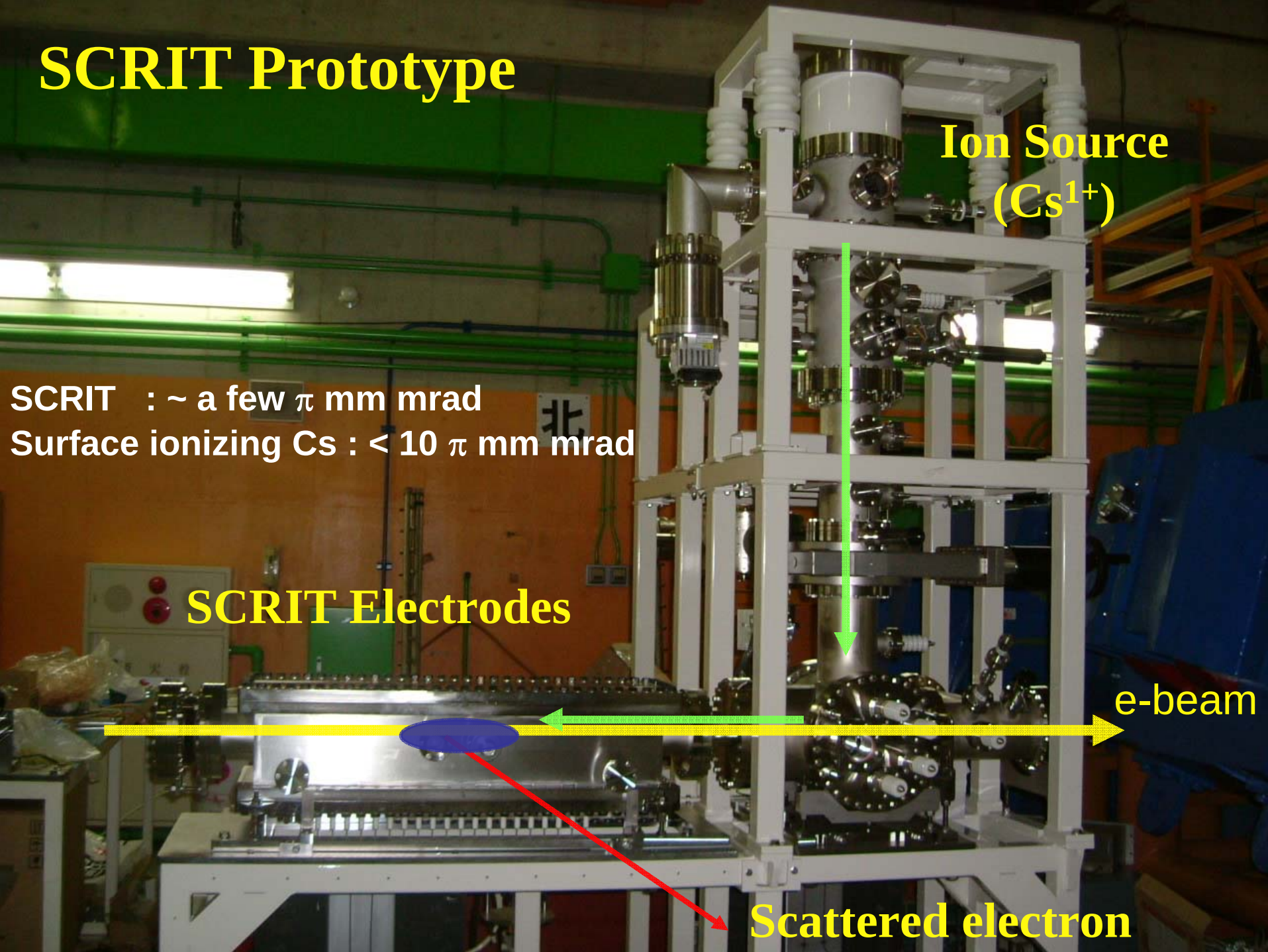
Slow RI beam generator

1. In-flight facility + gas catcher
2. ISOL (γ+U fission) : A~100,130 n-rich nuclei



SCRIT Prototype

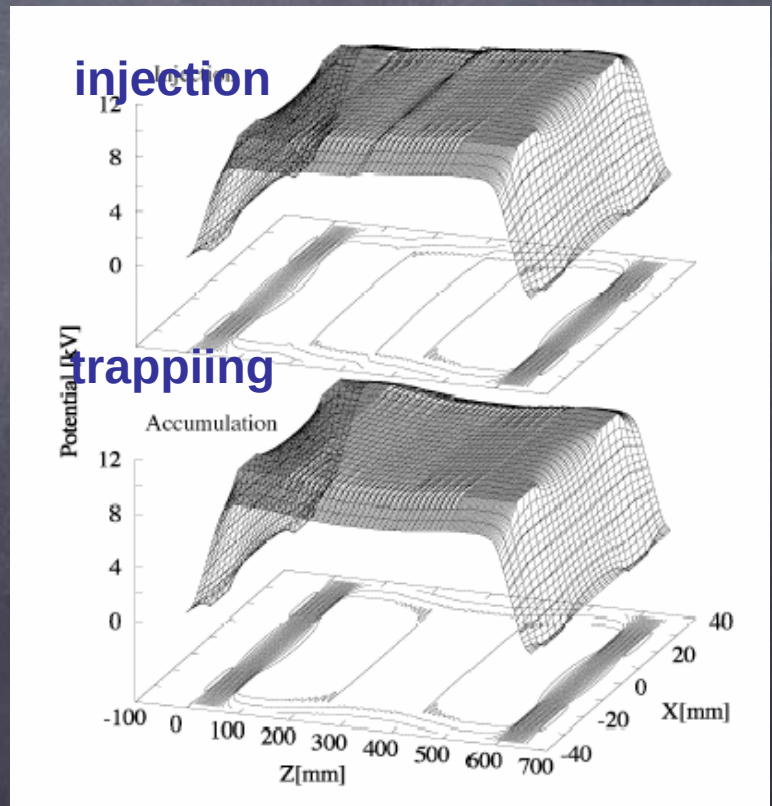



SCRIT Prototype
Ion Source
(Cs1+)
SCRIT : ~ a few π mm mrad
Surface ionizing Cs : < 10 π mm mrad
SCRIT Electrodes
e-beam
Scattered electron

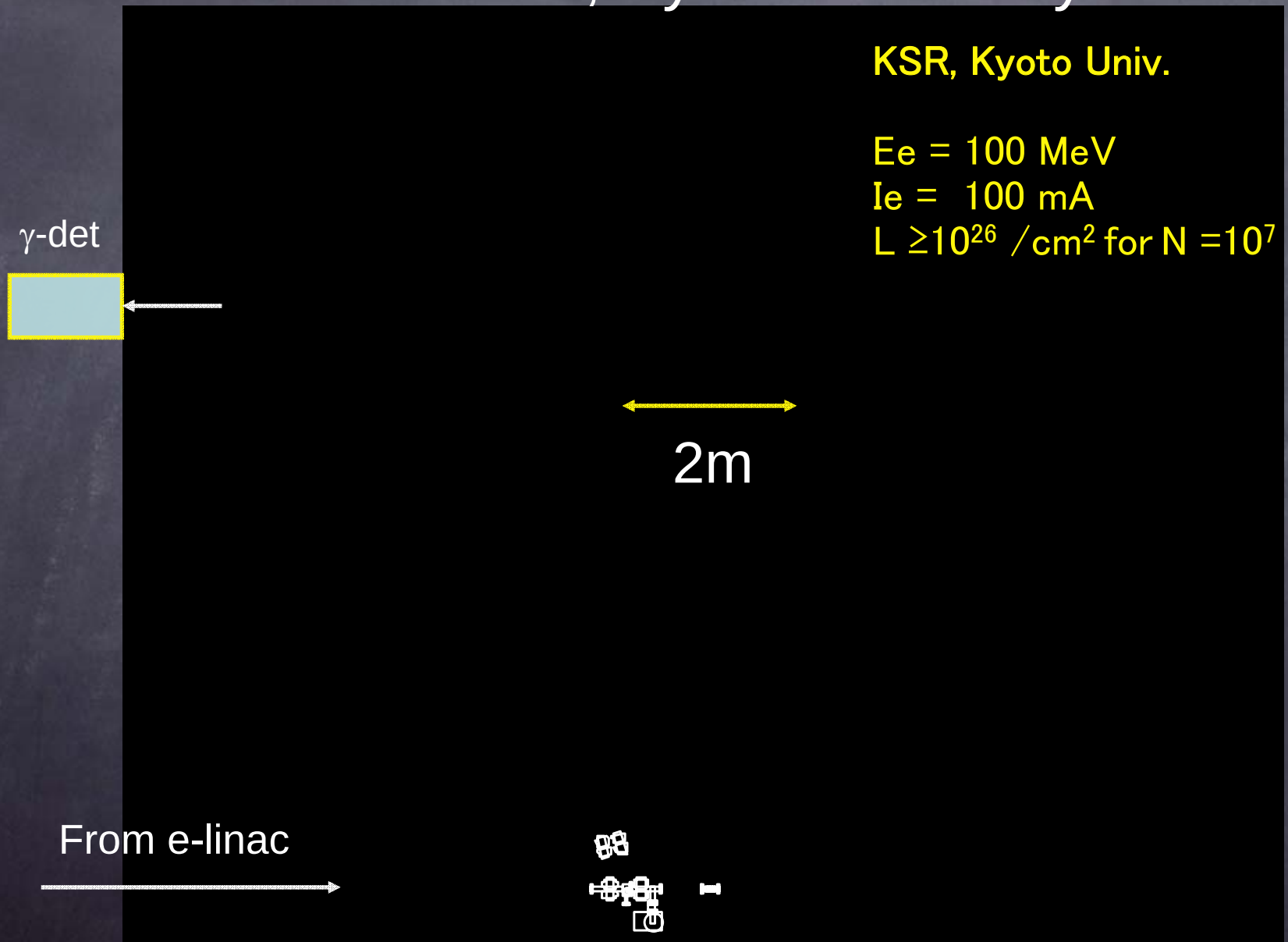
SCRIT electrodes for longitudinal trapping

42 electrodes to
form various potential shape

Cs ion : 10 kV
Trapping potential : 10 kV - δ



Feasibility study of the SCRIT scheme at KSR, Kyoto University



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Detector Setup

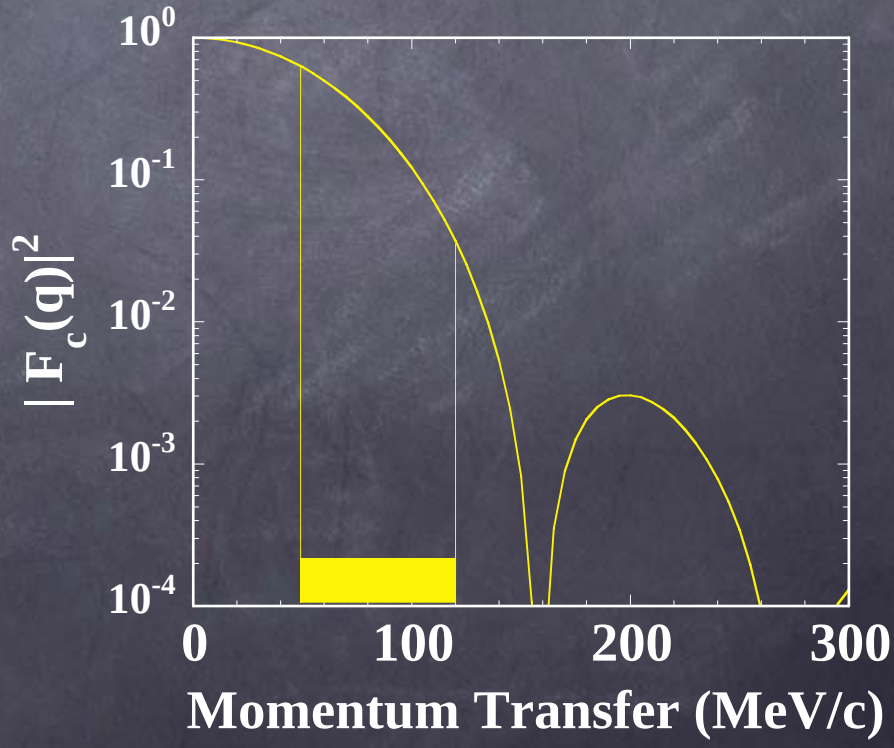
Luminosity Monitoring

Bremsstrahlung : a set of BaF2 detector ~100b
Characteristic X-ray (30keV) : a Ge detector ~30b
Ultra-forward elastic scattering ~1000b

Electron detector

Ee = 100 MeV
$\theta e \geq 30$ deg.
Elastic scattering dominates.

drift chamber
plastic scintillator
calorimeter

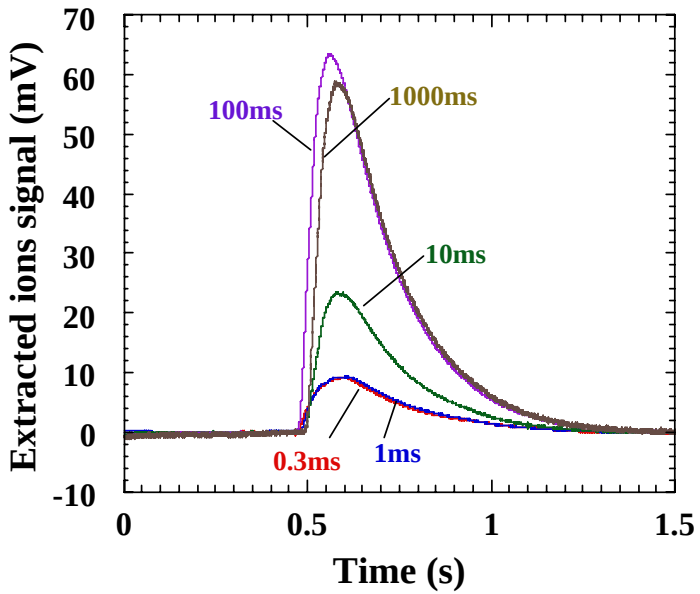


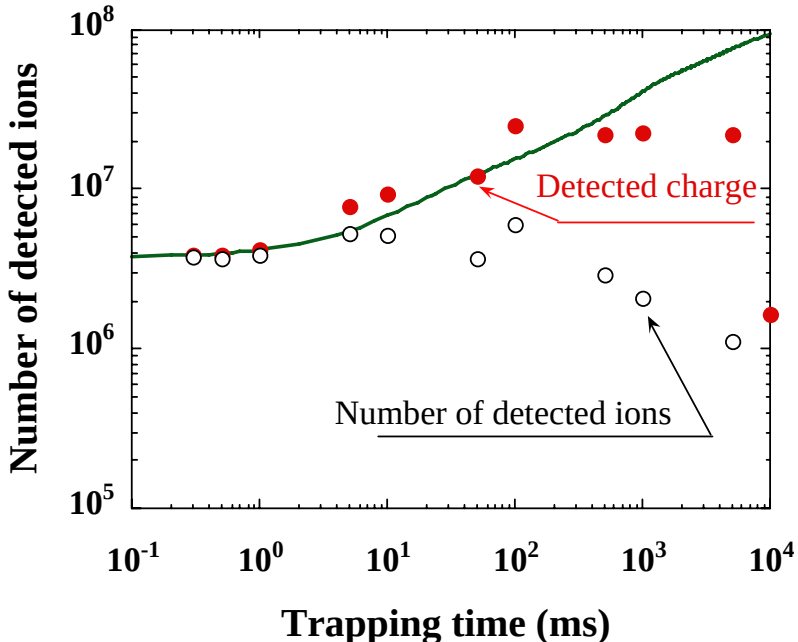
First result
Ion trapping by electron beam

Detection

Injection

Gate switching





Summary

- Electron scattering will be a really unique tool to study the internal structure of unstable nuclei.
- SCRIT will be one of ways to realize eRI scattering experiment at next generation RIB facilities.
- SCRIT R&D is now underway. The trapping of externally injected ions has been confirmed.
- Next step is the accurate determination of luminosity. The detection of elastically scattered electrons from Cs will be also carried out..

BaF2 (bremss.)

Ion clearers

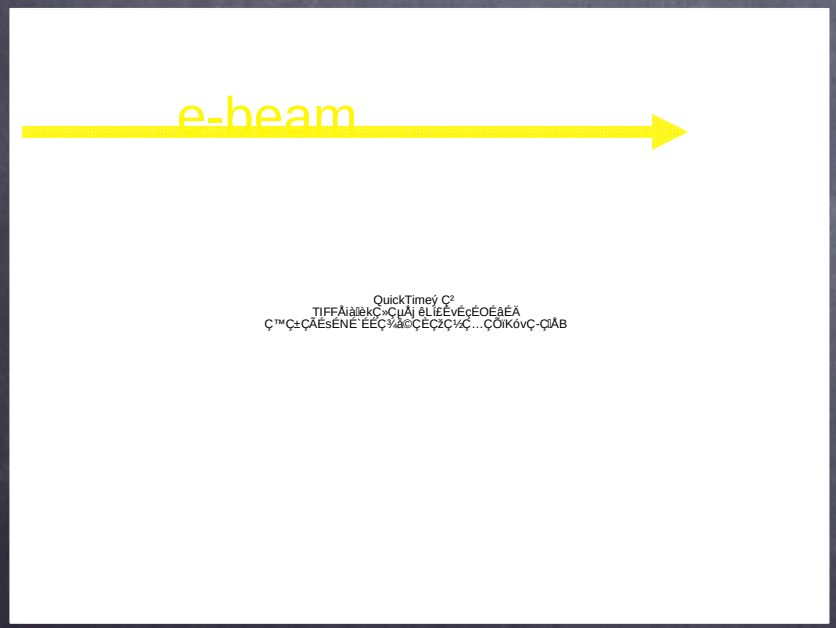
R&D studies at KSR

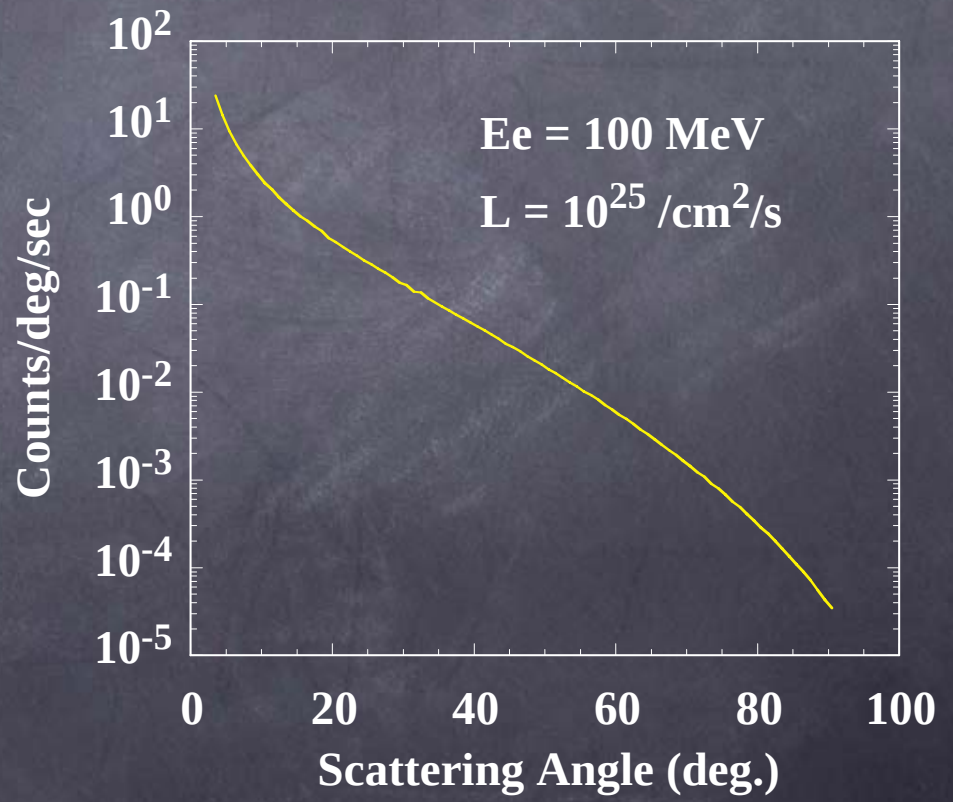
Ee = 100 MeV

θe ≥ 30 deg.

Elastic scattering dominates.

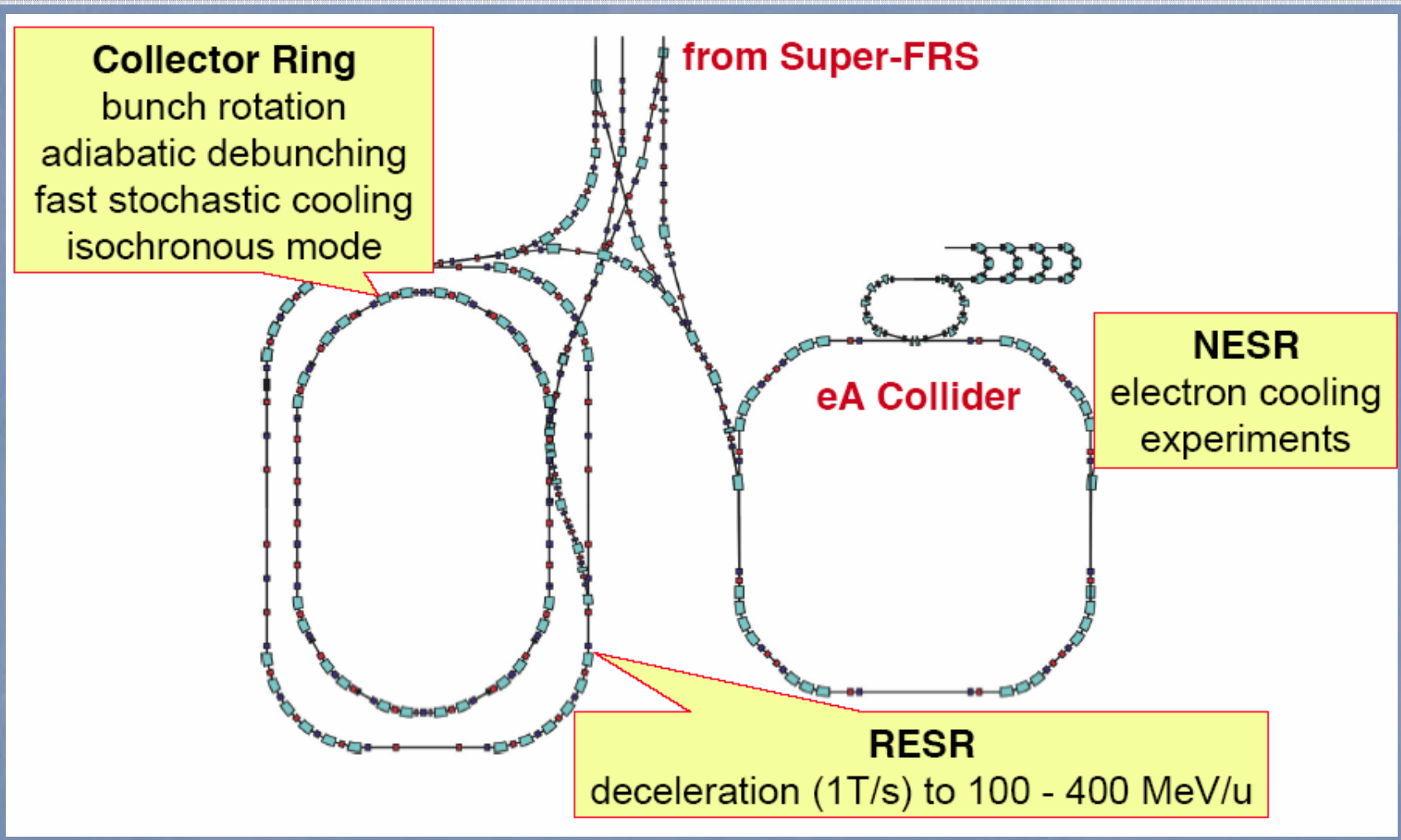
Expected luminosity at KSR $10^{26}/cm^2/s$ for $N_{ion}=10^7$





Electron - RI collider

Planned in the GSI project

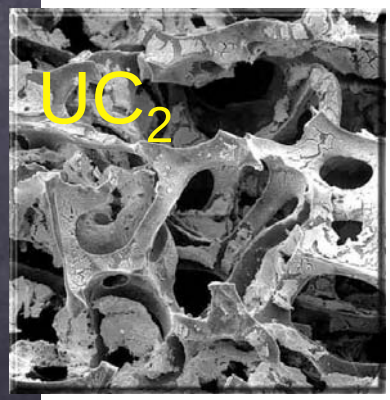


From H. Simon

SCRIT at RIBF (conceptual)

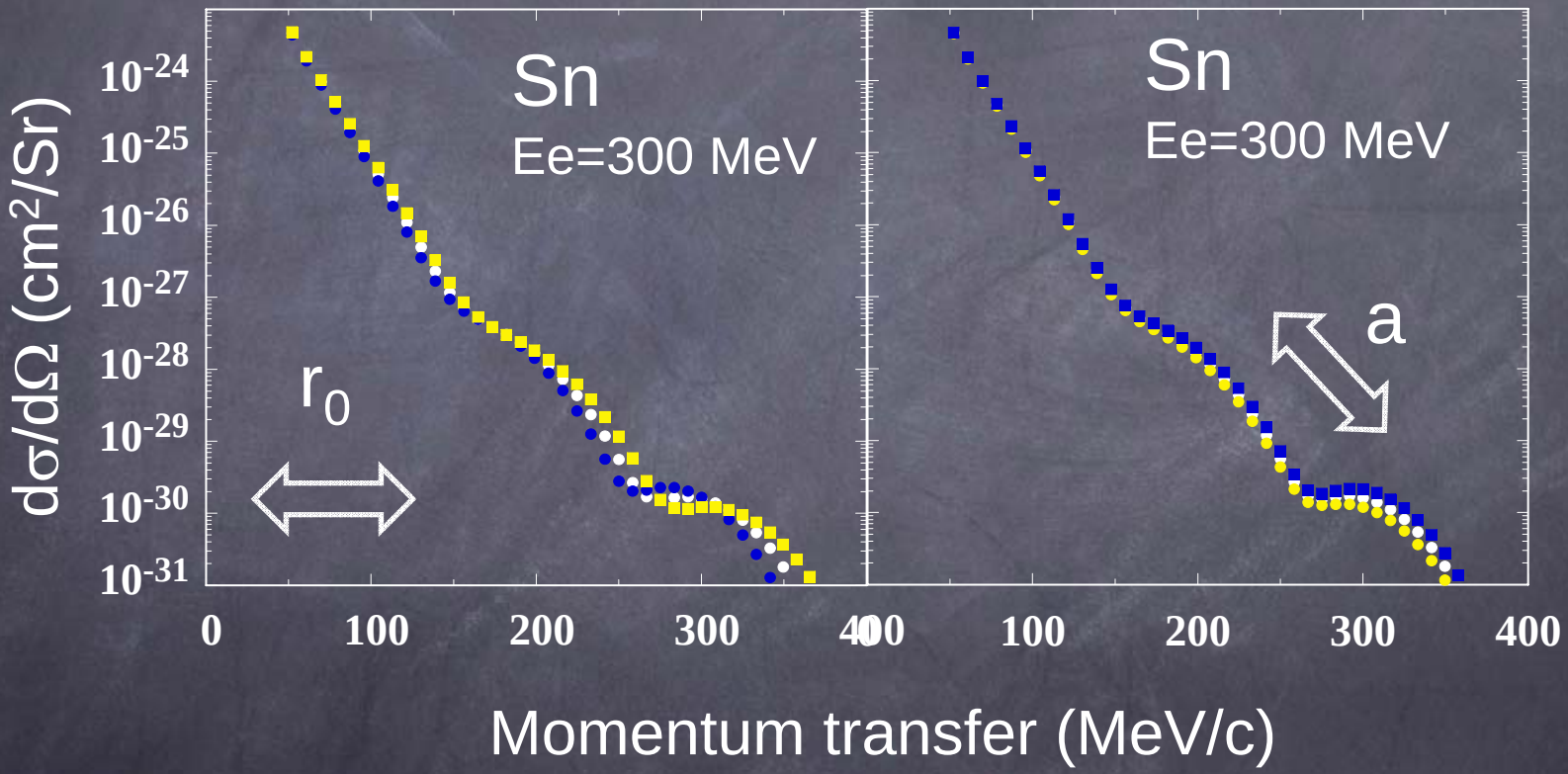
Slow RI beam generator

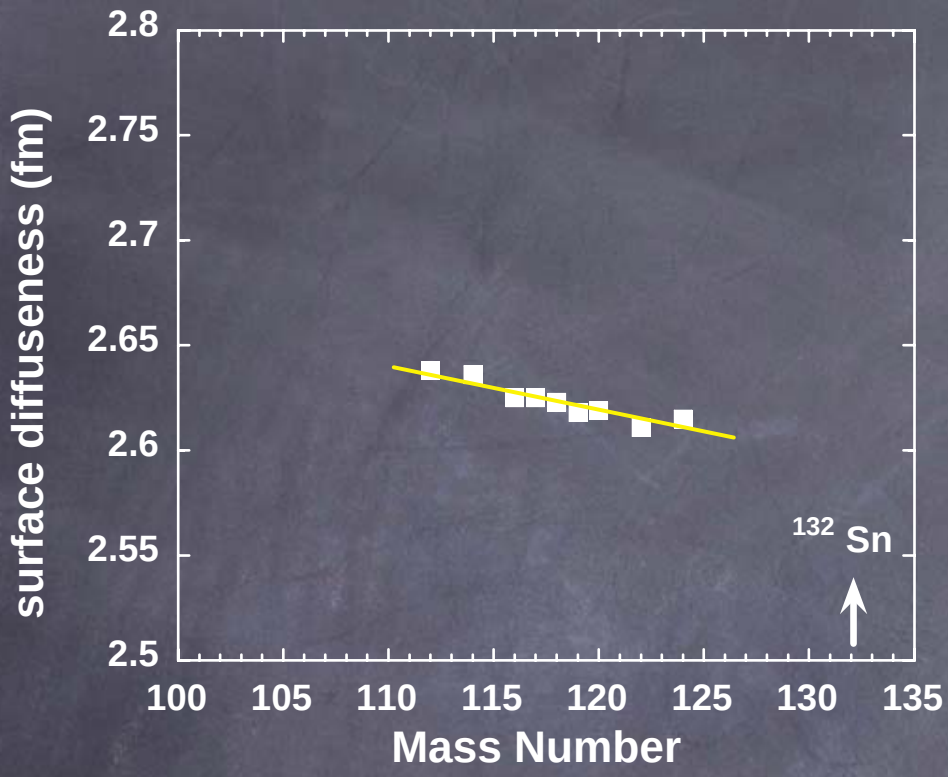
1. Fragment separator + gas catcher
2. ISOL (γ + U)

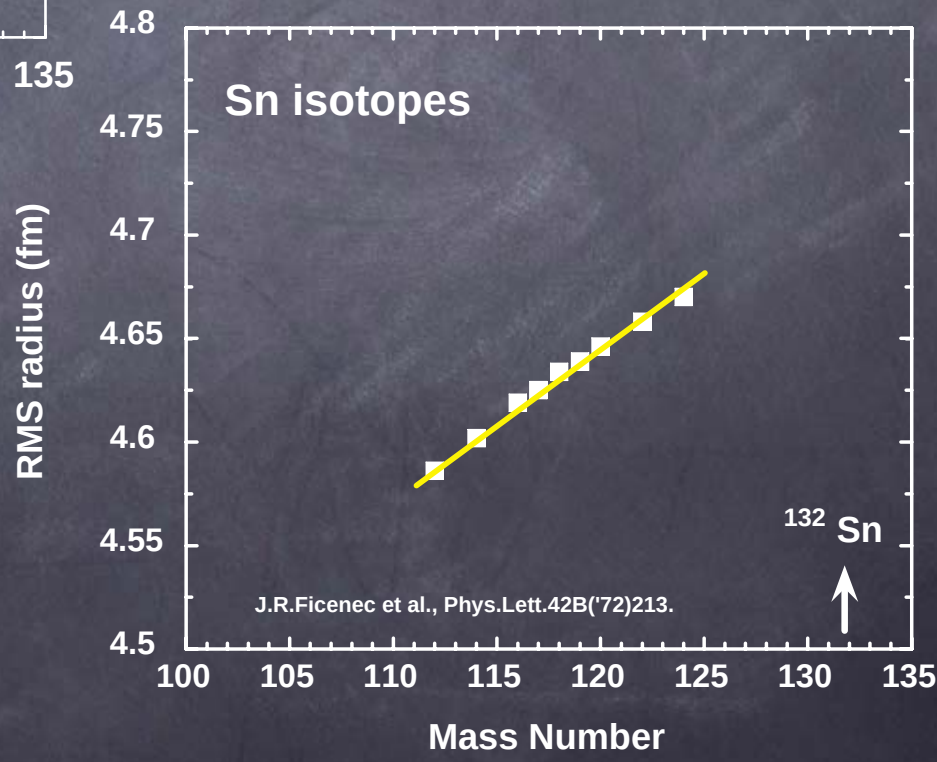


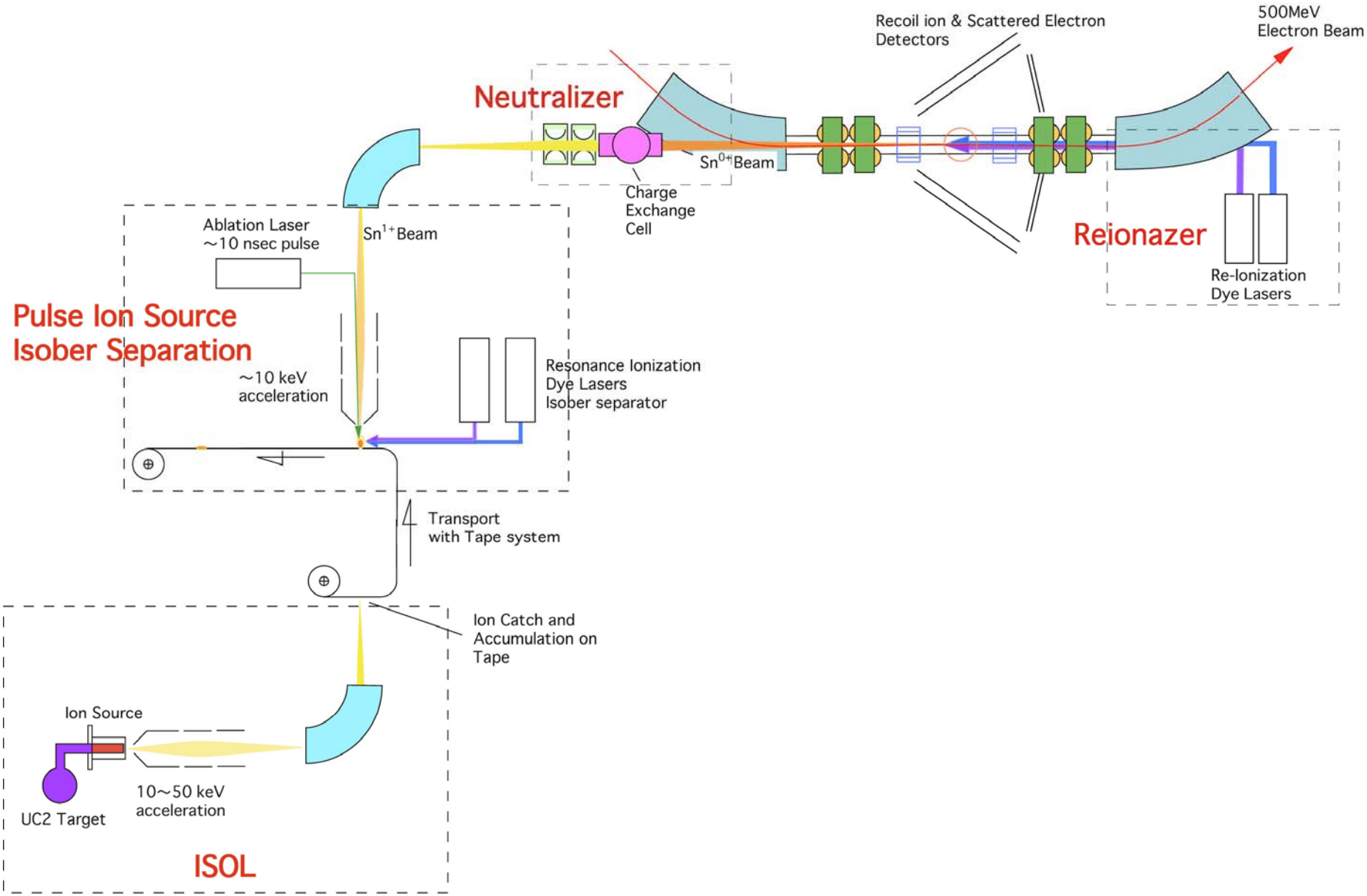
DREPHA results

Distorted wave calculation




surface diffuseness (fm)
2.8
2.75
2.7
2.65
2.6
2.55
2.5
100
105
110
115
120
125
130
135
Mass Number
132 Sn


RMS radius (fm)
4.8
4.75
4.7
4.65
4.6
4.55
4.5
Sn isotopes
J.R.Ficenec et al., Phys.Lett.42B('72)213.
132 Sn
100
105
110
115
120
125
130
135
Mass Number


Recoil ion & Scattered Electron Detectors
500MeV Electron Beam
Neutralizer
Sn0+ Beam
Charge Exchange Cell
Reionazer
Re-Ionization Dye Lasers
Ablation Laser ~10 nsec pulse
Sn1+ Beam
Pulse Ion Source Isober Separation
~10 keV acceleration
Resonance Ionization Dye Lasers Isober separator
Transport with Tape system
Ion Catch and Accumulation on Tape
Ion Source
10~50 keV acceleration
UC2 Target
ISOL