Current Status of Electron-RI Collision Project at RIKEN

M. Wakasugi

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SCRIT Collaboration

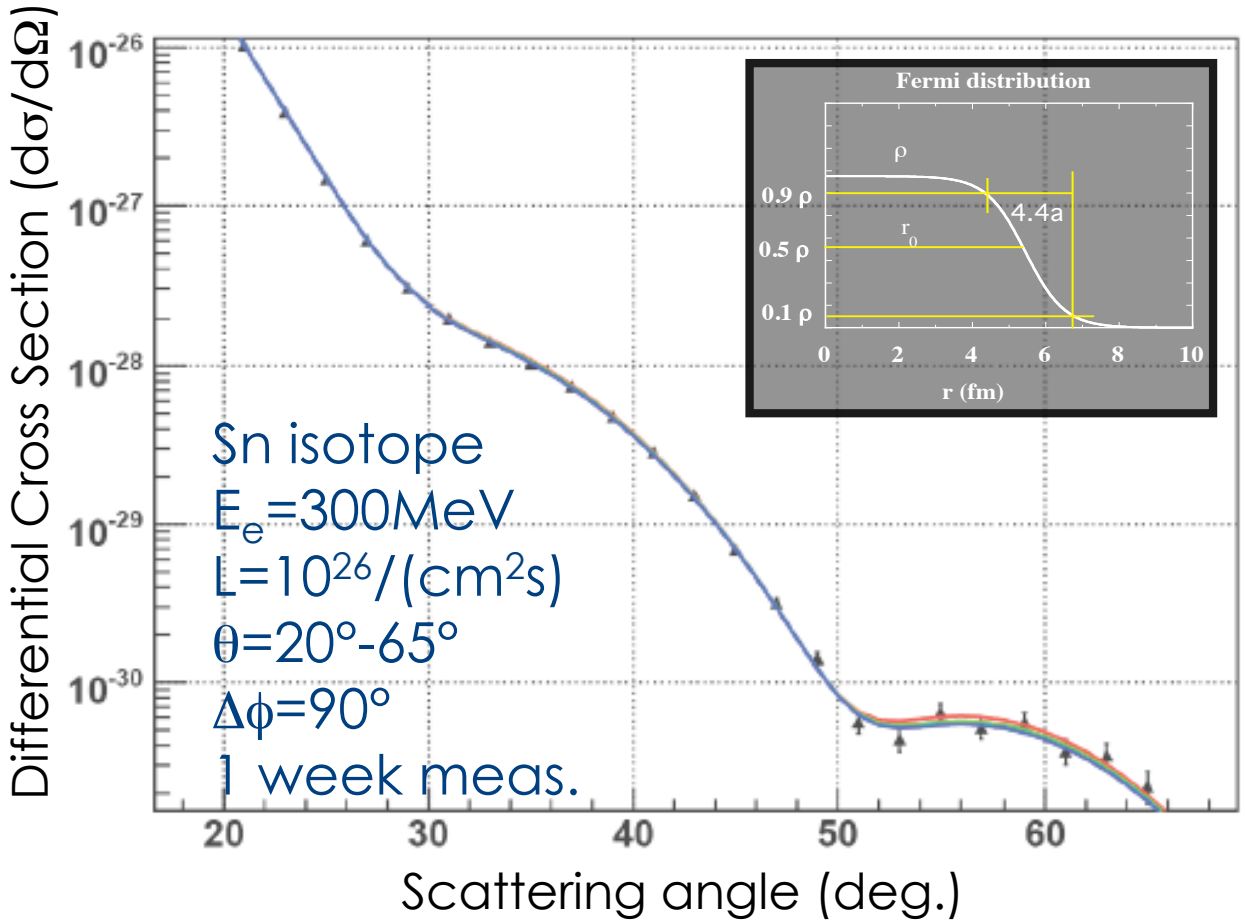
RIKEN Nishina Center for Accelerator-Based Science
T. Ohnishi, M. Watanabe, S. Ichikawa, M. Hara, T. Hori

Department of Physics, Rikkyo University
M. Togasaki, K. Yamada, T. Hujita, K. Adachi, M.Hori, A. Enokizono, K. Kurita

Research Center for Electron Photon Science, Tohoku University
K. Tsukada, T. Tamae, T. Suda

Current Status of Electron-RI Collision Project at RIKEN

Charge density distribution from elastic scattering



Luminosity
> 10^{26} /(cm^2s)

Cross section measurement until second maximum

Determination of radii and diffuseness with a few % accuracy

Current Status of Electron-RI Collision Project at RIKEN

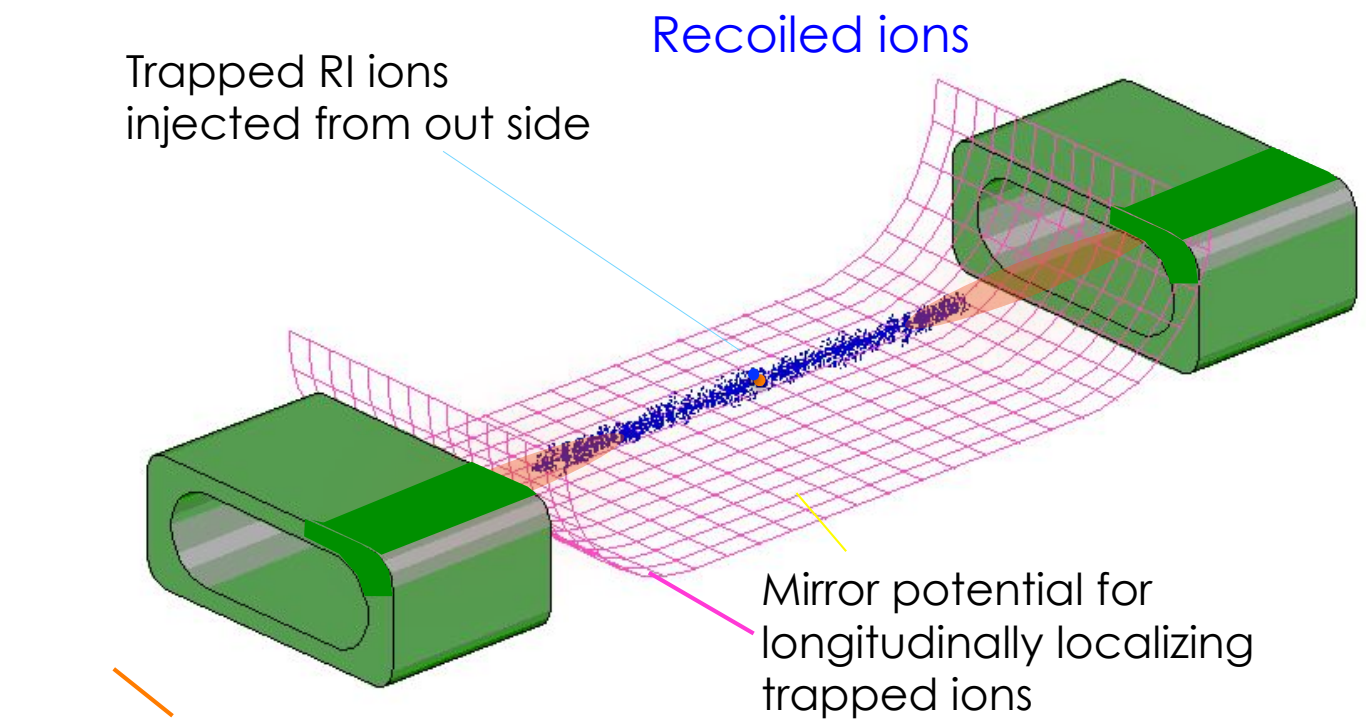
Brief history of the project

- In 1995, the project was proposed.
  Design study of e-RI collider ring was started.
- In 2002, experimental scheme was changed to the SCRIT method.
- In 2007, feasibility study of the SCRIT method was succeeded.
- In 2009, the SCRIT facility construction was started.
- In this year, the construction has been almost completed.
- The facility is now under comprehensive test.

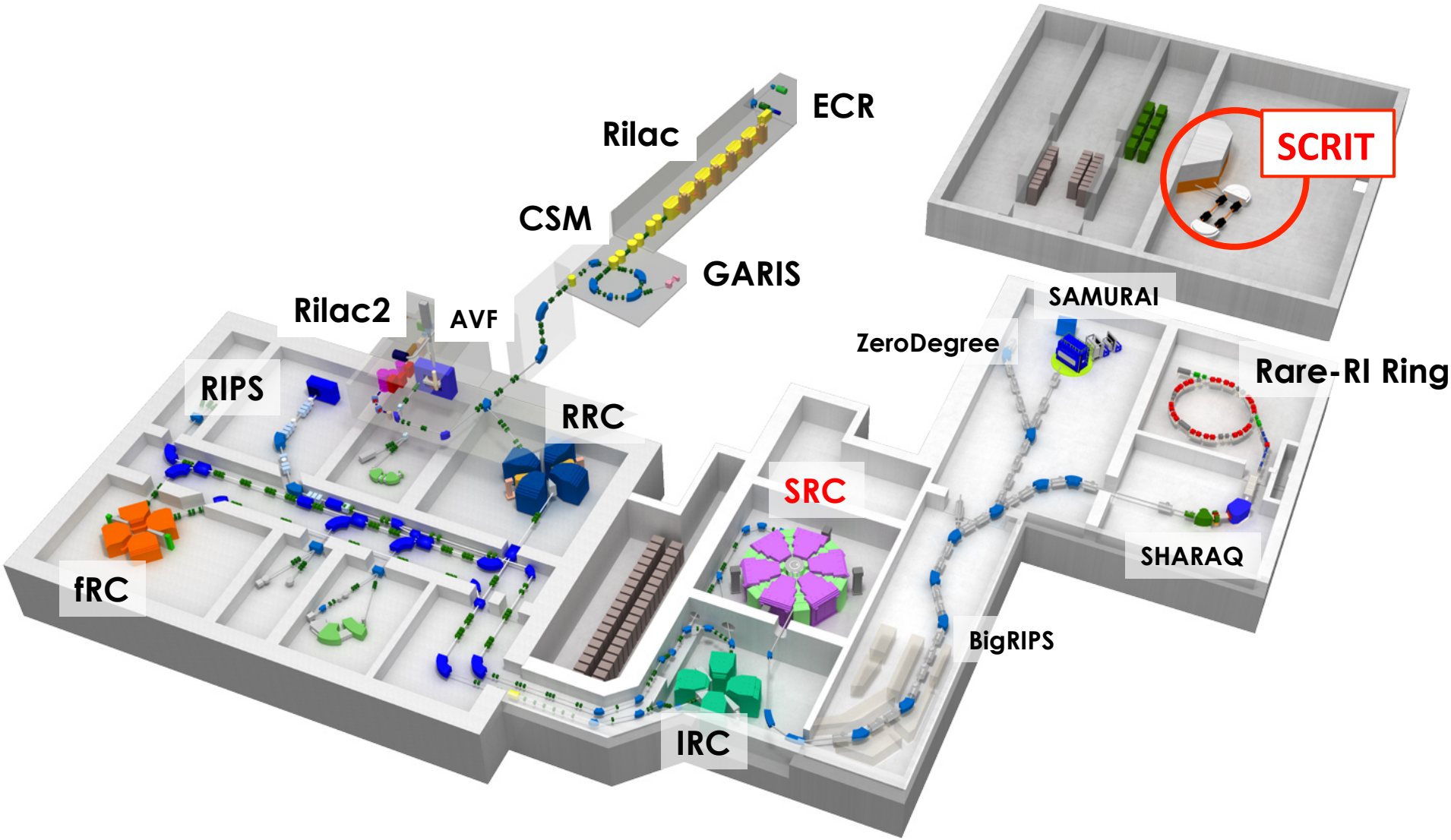
SCRIT (Self-Confining RI Ion Target)

SCRIT is internal-target-forming technique in an electron storage ring.

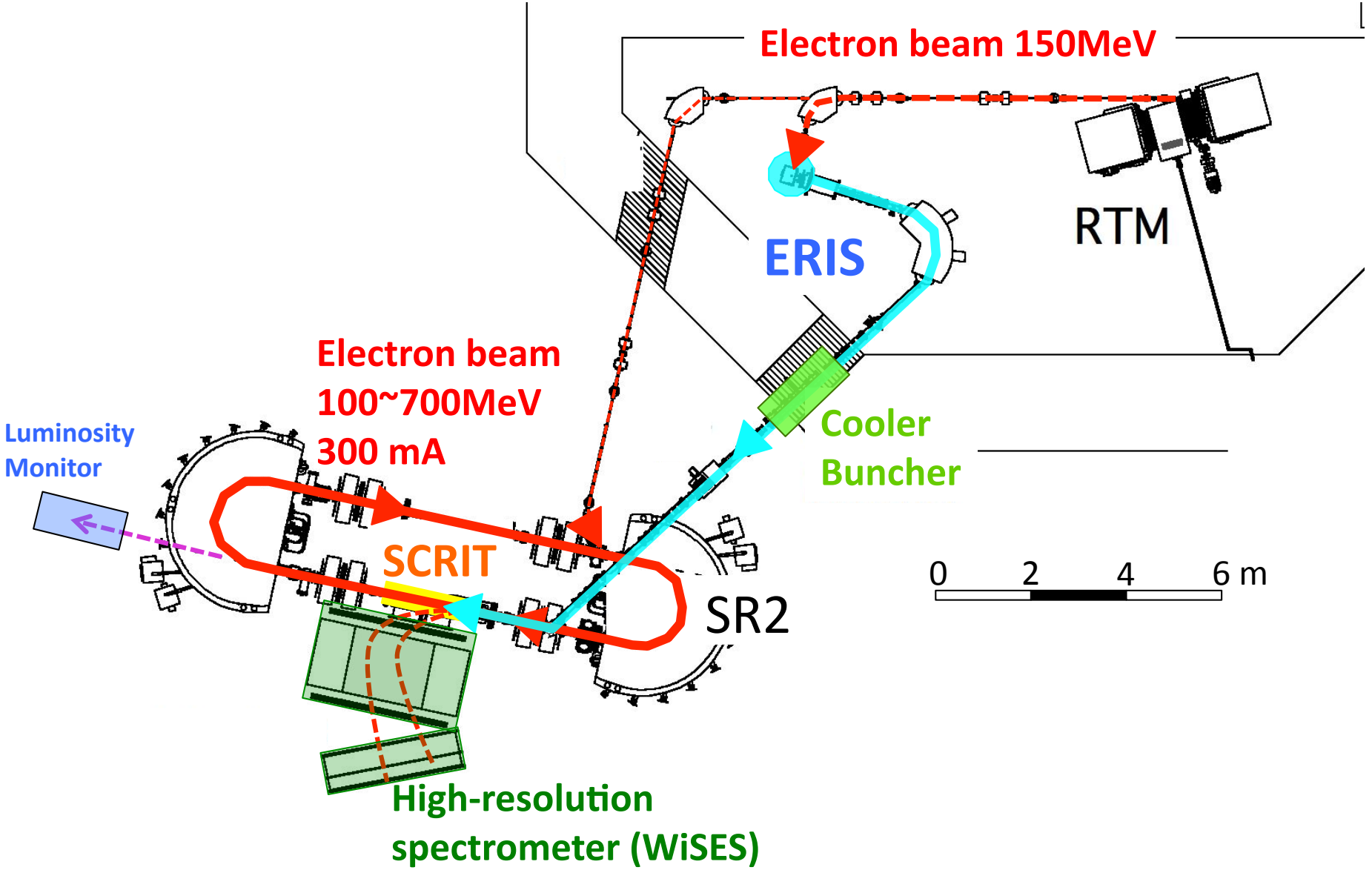
Target ions are confined in the beam orbit by periodic focusing force.



Location of the SCRIT Facility in RIKEN RI Beam Factory



The SCRIT Electron Scattering Facility



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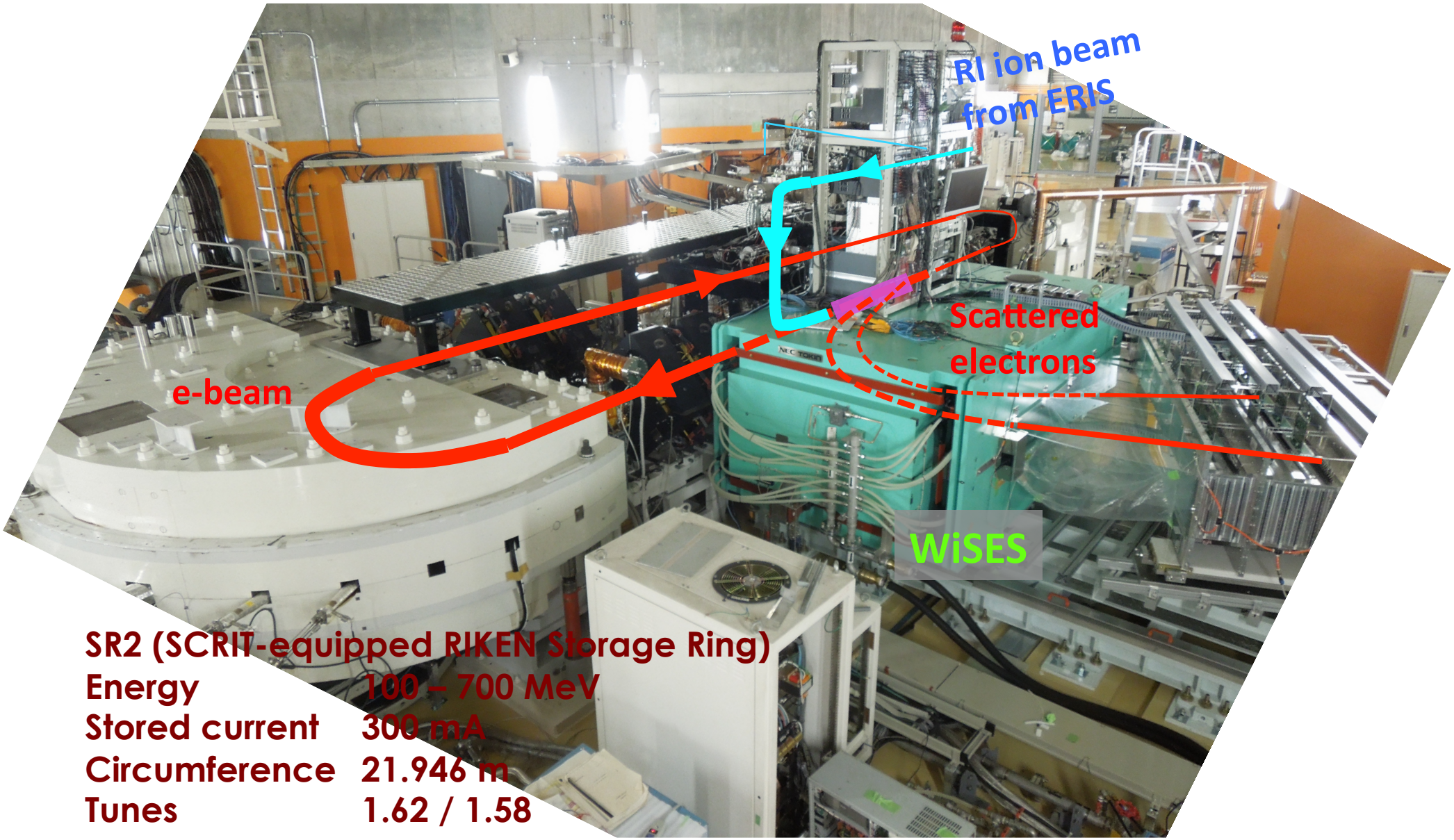
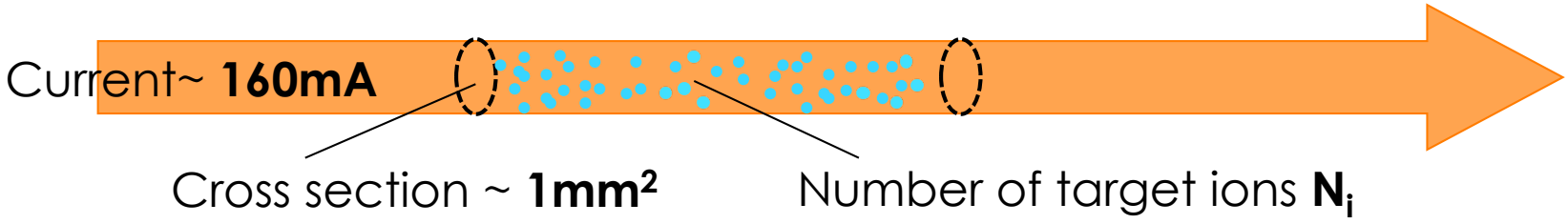


SR2 (SCRIT-equipped RIKEN Storage Ring)

Energy	100 – 700 MeV
Stored current	300 mA
Circumference	21.946 m
Tunes	1.62 / 1.58

SCRIT and its Performances

Simple Estimation of Achievable Luminosity



Luminosity ~ N_i × 10^{20} /(cm^2s)

Required luminosity
10^{26} /(cm^2s)

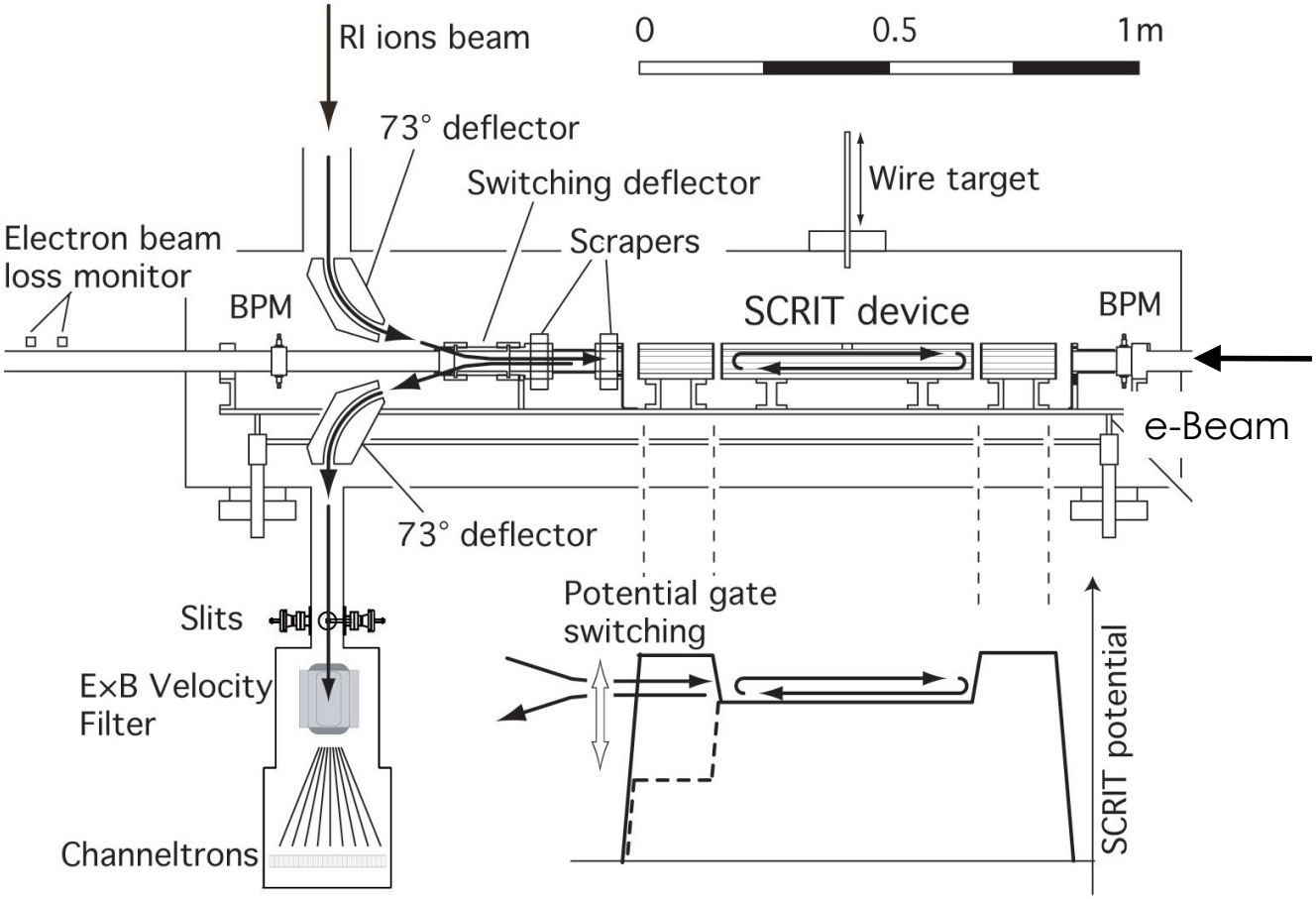
⇨

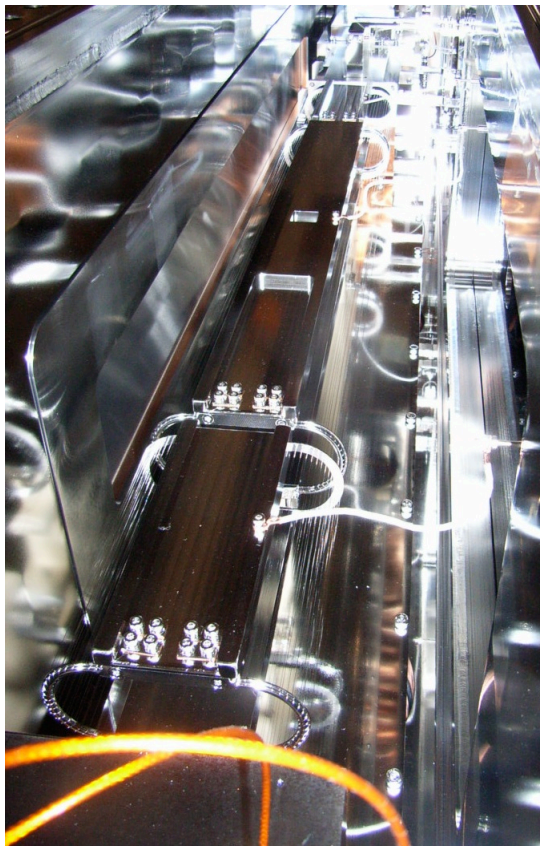
Number of target ions
~10^6 ions

Actually, we have : Charge state multiplication
Decay of target ions due to interactions with electron beam, residual gas ions, wake field.....
Decay of electron beam current

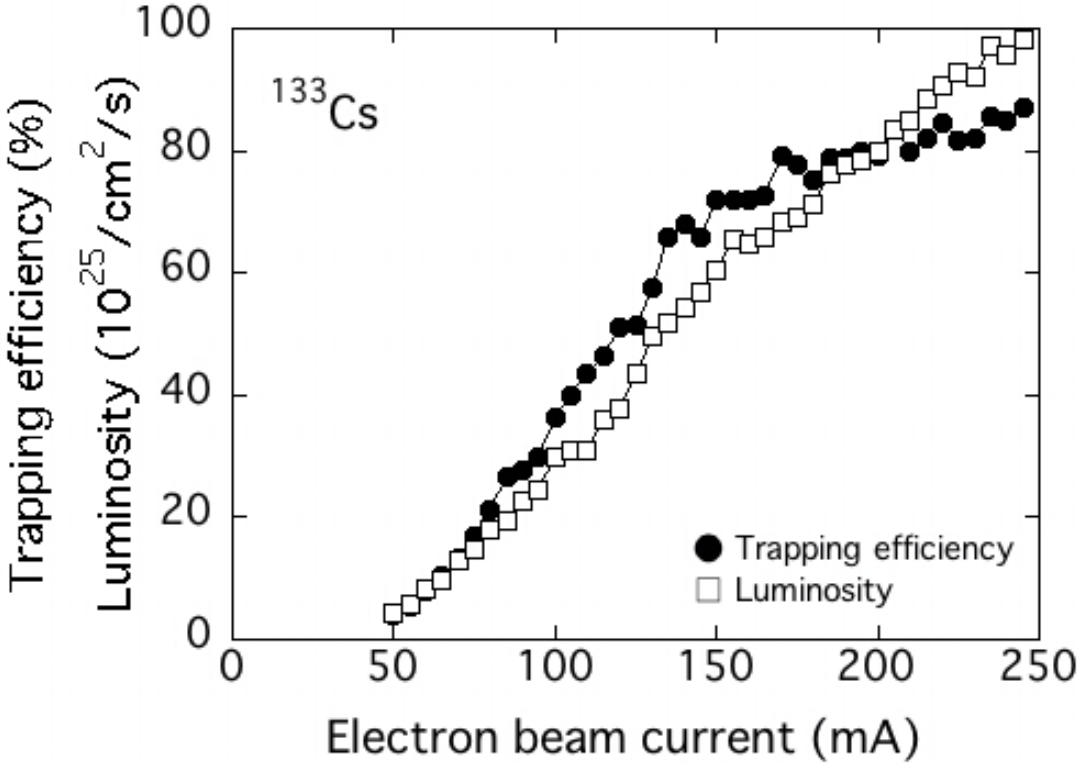
⇨ **Luminosity is not stable**

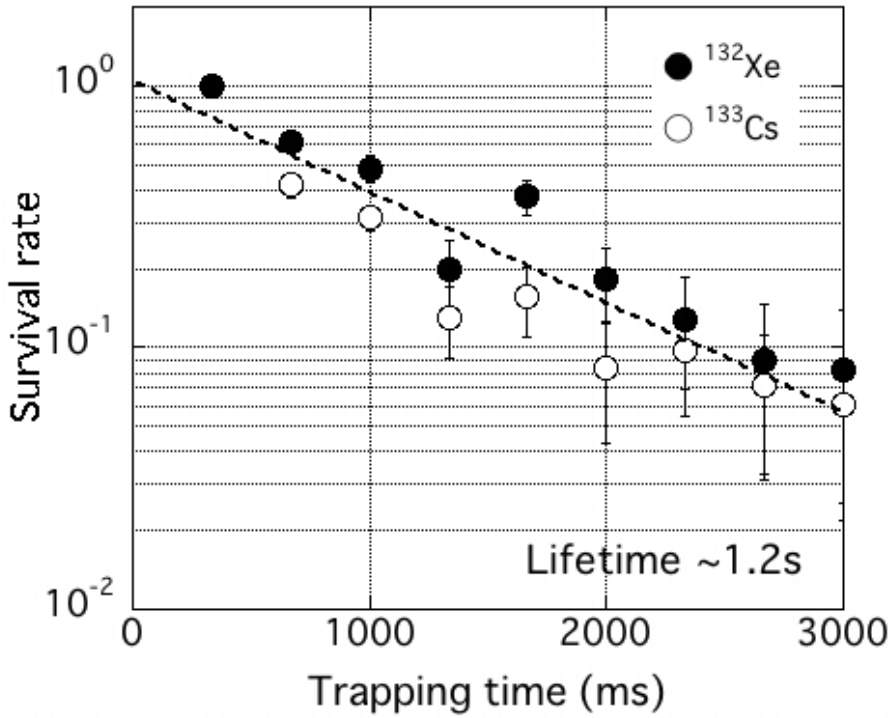
SCRIT Devise Installed in SR2





Performance of Ion trapping in the SCRIT





At 250mA:

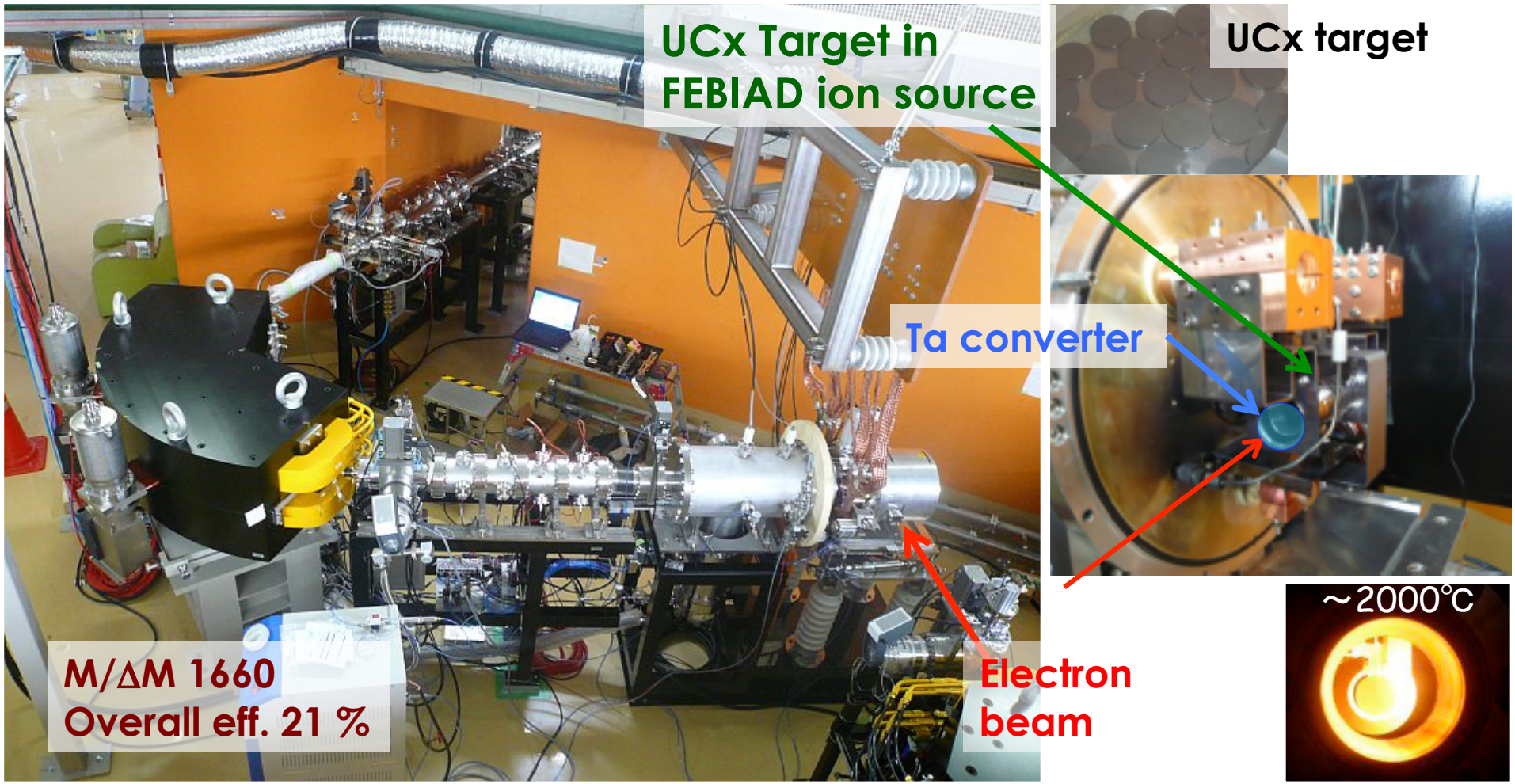
Trapping efficiency ~90 %

Trapping lifetime > 1s

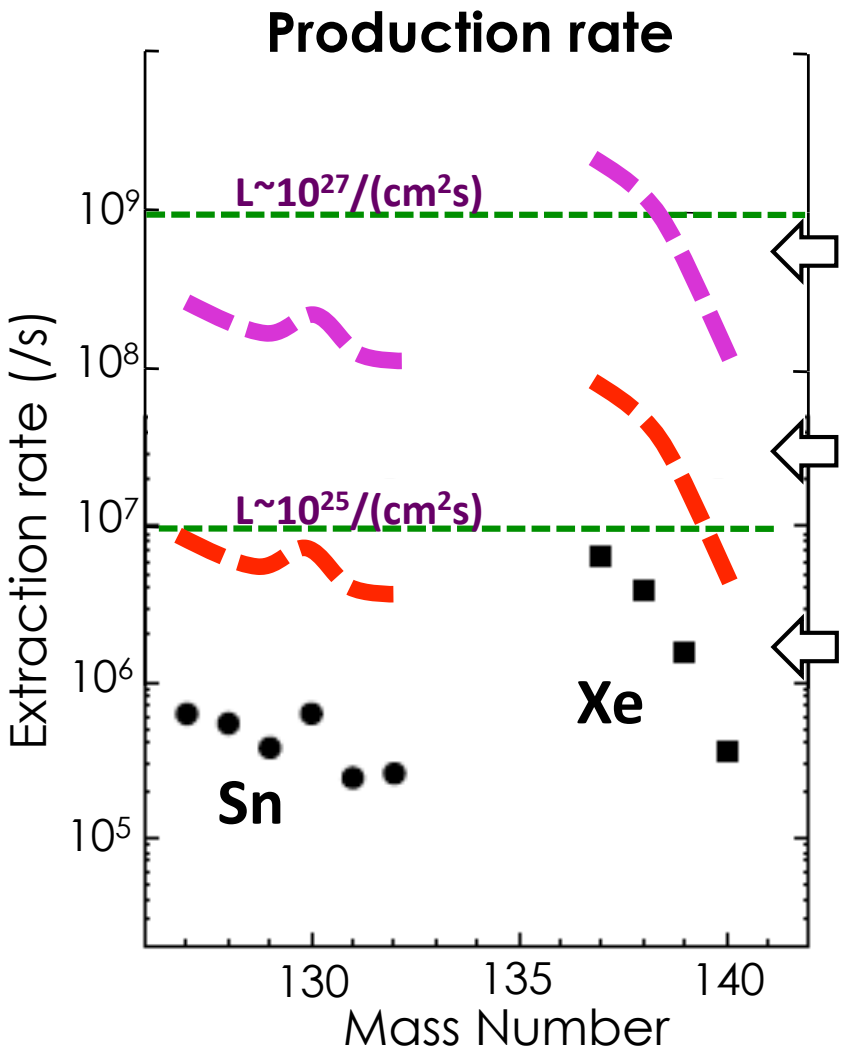
Collision luminosity ~10^{27}/cm^2/s
(with 3x10^7 ions)

RI Production and Buncher for Ion Injection to SCRIT

ERIS (Electron-beam-driven RI separator for SCRIT)



RI Beam Production at ERIS



Expected
U **30g**, e-Beam **2kW**

Expected
U **30g**, e-Beam **50W**

Achieved in 2014
U **15g**, e-Beam **10W**

Upgrade of RTM e-Beam

5mApeak
8μs pules
400Hz repetition
Planned

5mApeak
4μs pules
20Hz repetition
In progress

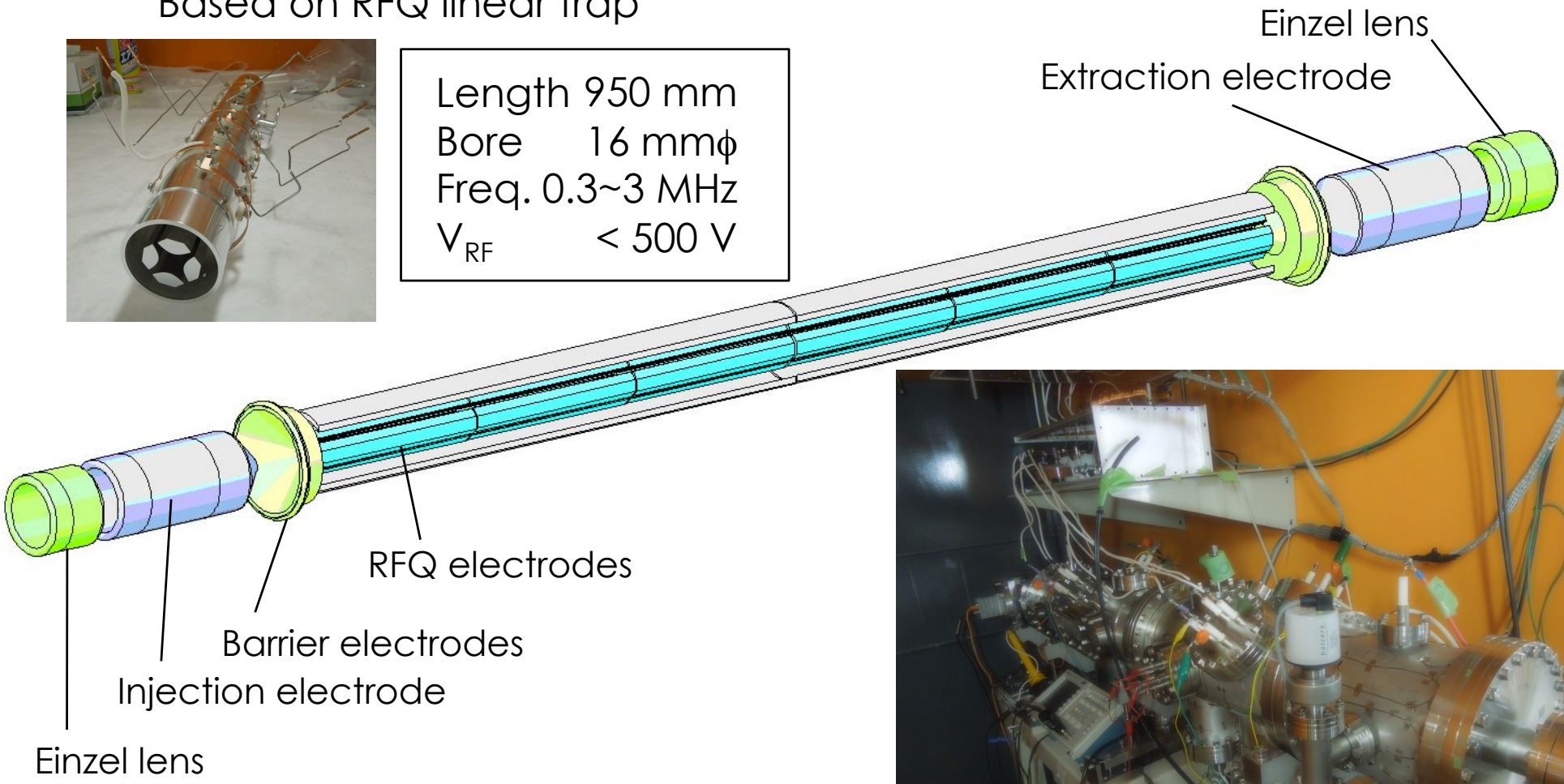
1.5mApeak
4μs pules
10Hz repetition
Current

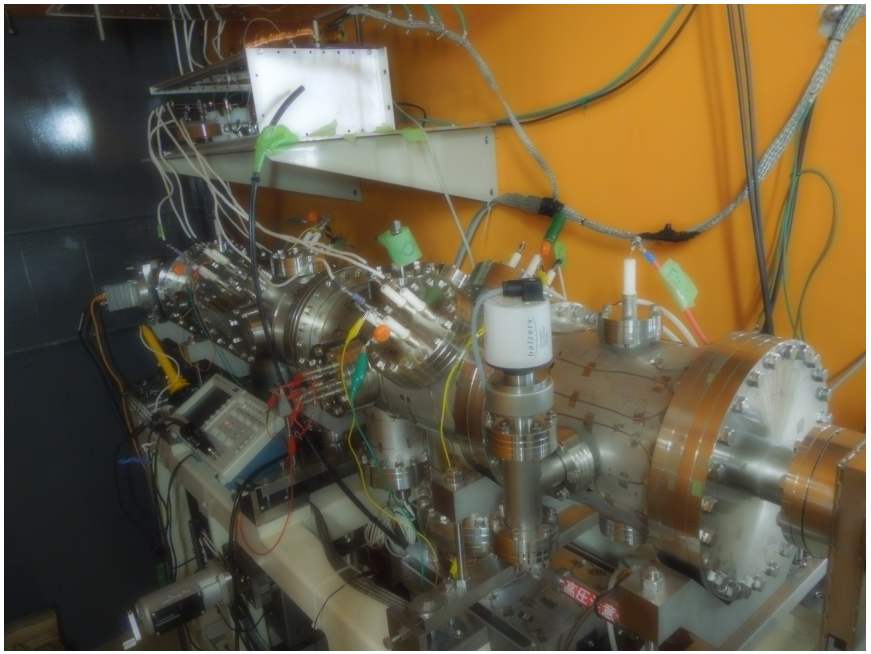
Cooler Buncher Device for Ion Injection to SCRIT

Cooler Buncher converts DC beam to 500μs pulsed beam

Based on RFQ linear trap

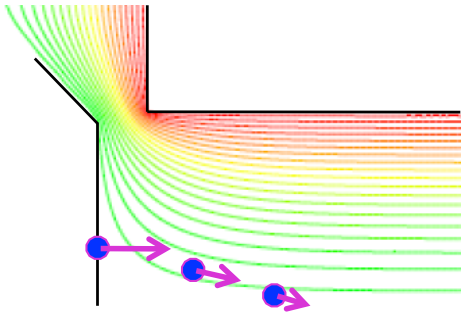
Length 950 mm
Bore 16 mmϕ
Freq. 0.3~3 MHz
V_{RF} < 500 V



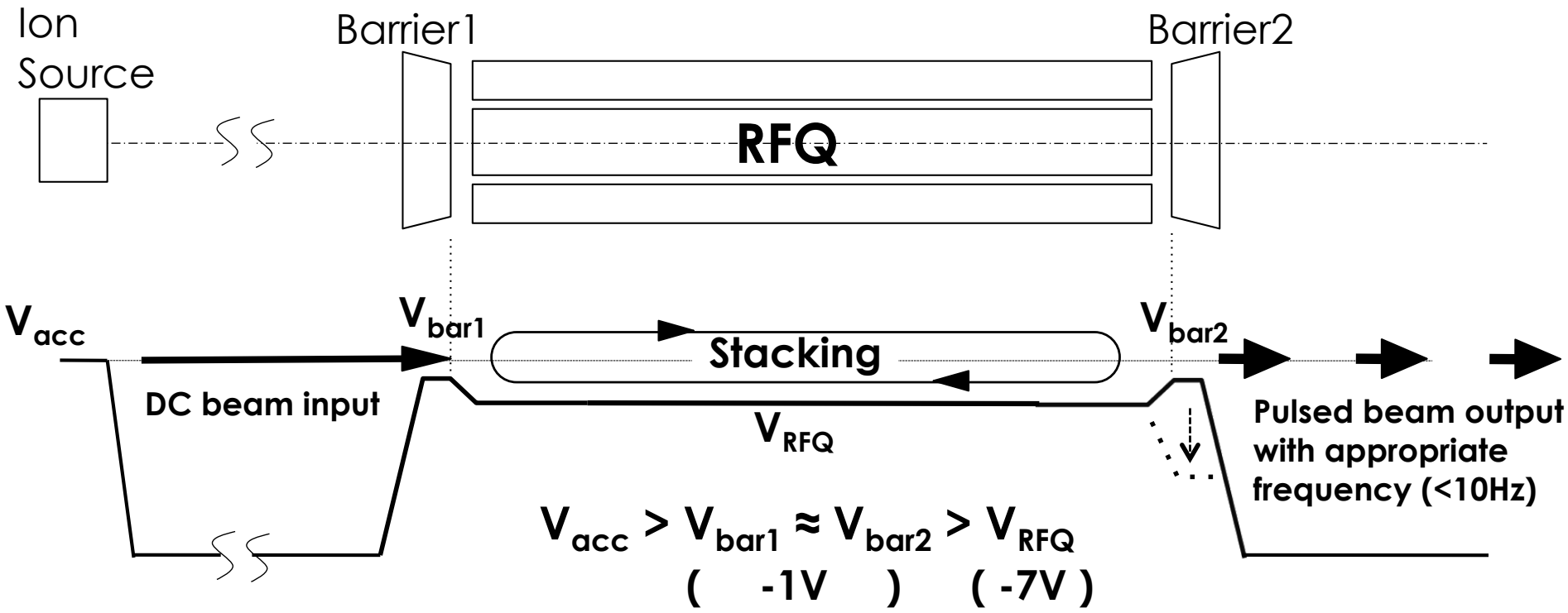


Buffer-Gas Free Cooler Buncher for Low-Energy Ion Beam

DC beam is stacked in RFQ by **flinging RF field effect** at the entrance

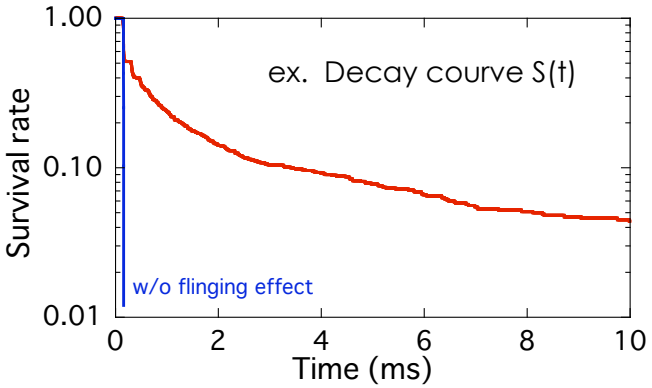


Injected ions are decelerated by flinging field and they are stacked in the RFQ



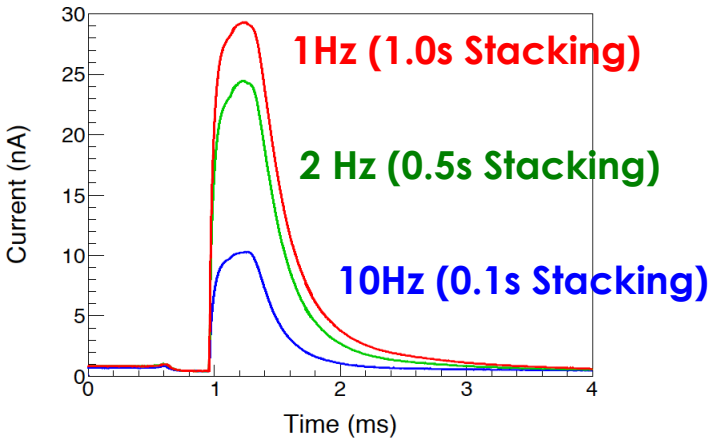
Buffer-Gas Free Cooler Buncher for Low-Energy Ion Beam

Stacked ions slowly decay



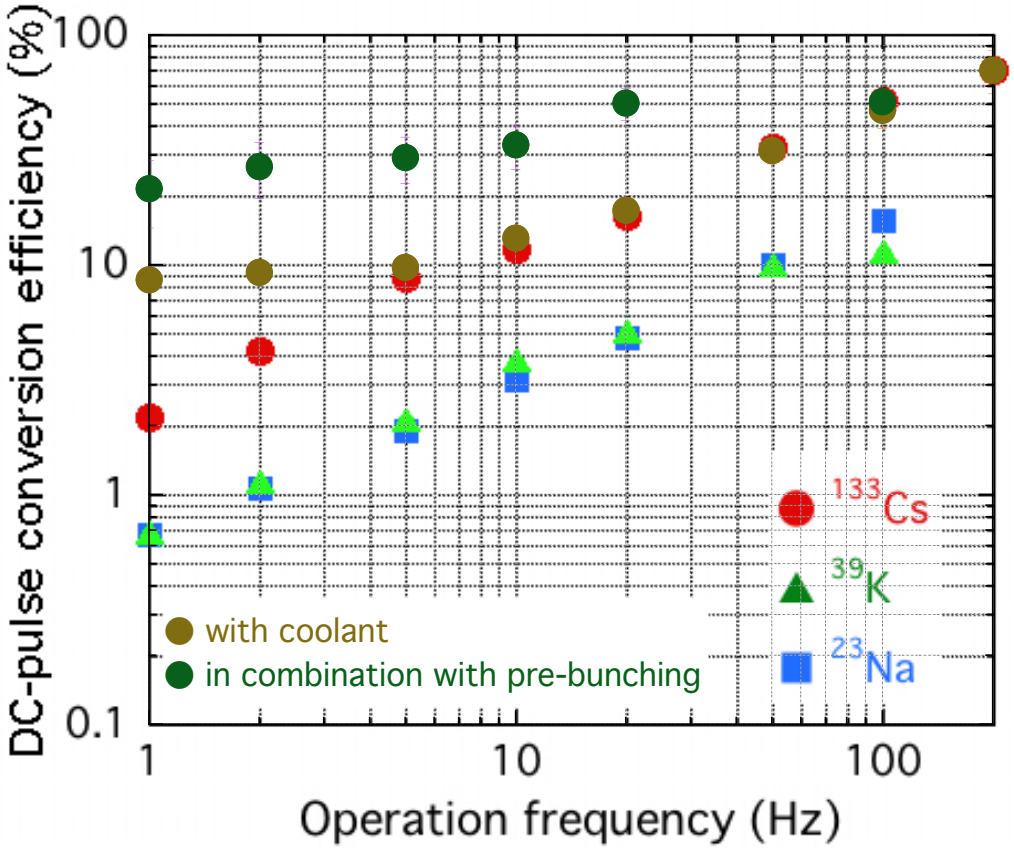
Number of stacked ions N(t) :

$$N(t) = I_{DC} \int_0^t S(t-t')\,dt'$$



DC-Pulse conversion efficiency

$$\varepsilon = \frac{N(1/f_{ope})}{I_{DC}} f_{ope}$$



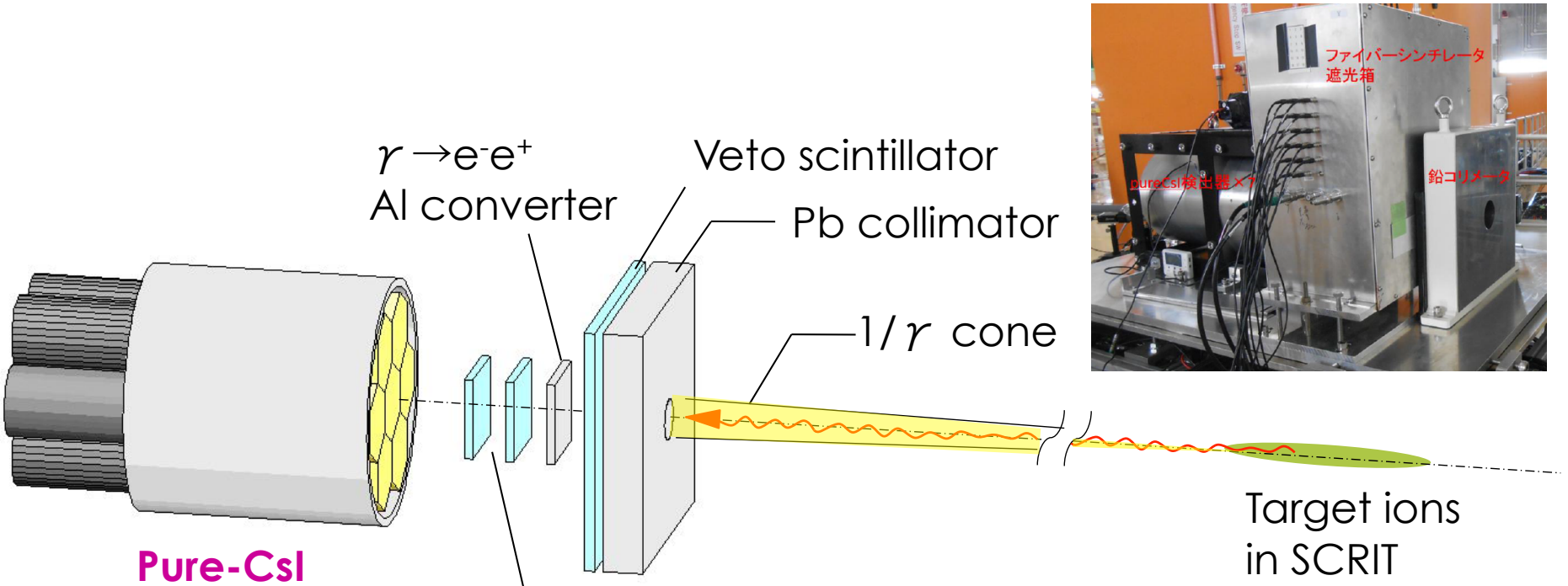
Luminosity Monitors and Scattered Electron Detectors

On-line Luminosity Monitor

Bremsstrahlung gamma ray created by target ions :

Absolute value of luminosity is obtained from the counting rate.

It is ensured by measuring the energy spectrum and the spatial distributions.



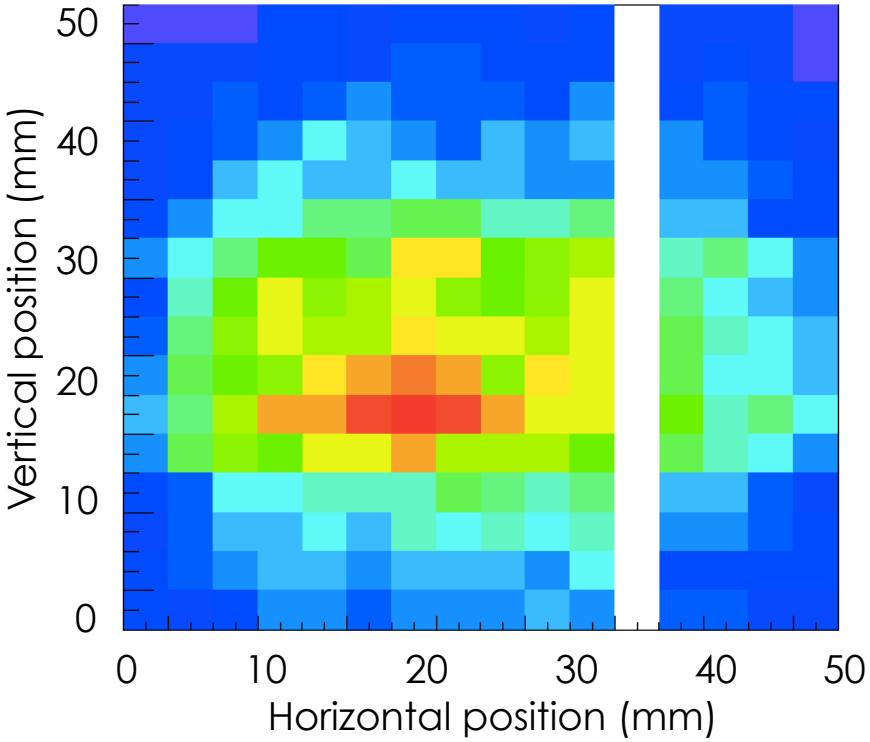
On-line Luminosity Monitor

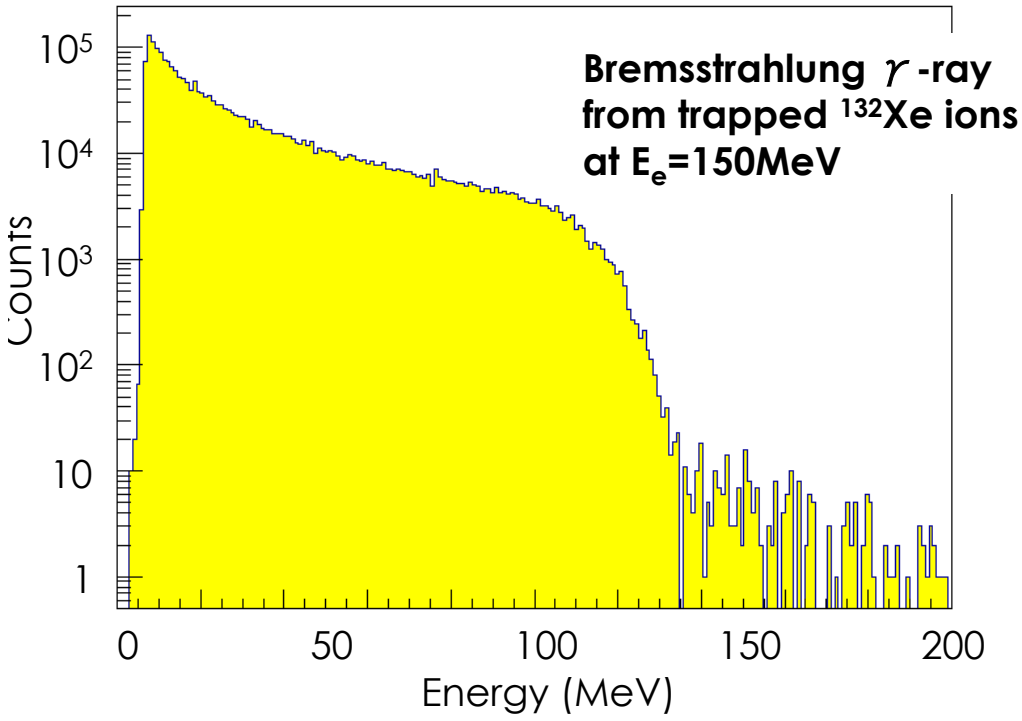
Counting rate is 40kHz at L=10^{27} /(cm^2s) and 150MeV
Accuracy is a few %

Spatial distribution of
Bremsstrahlung gamma ray
from ^{132}Xe target at E_e=150MeV

Absolute value of luminosity

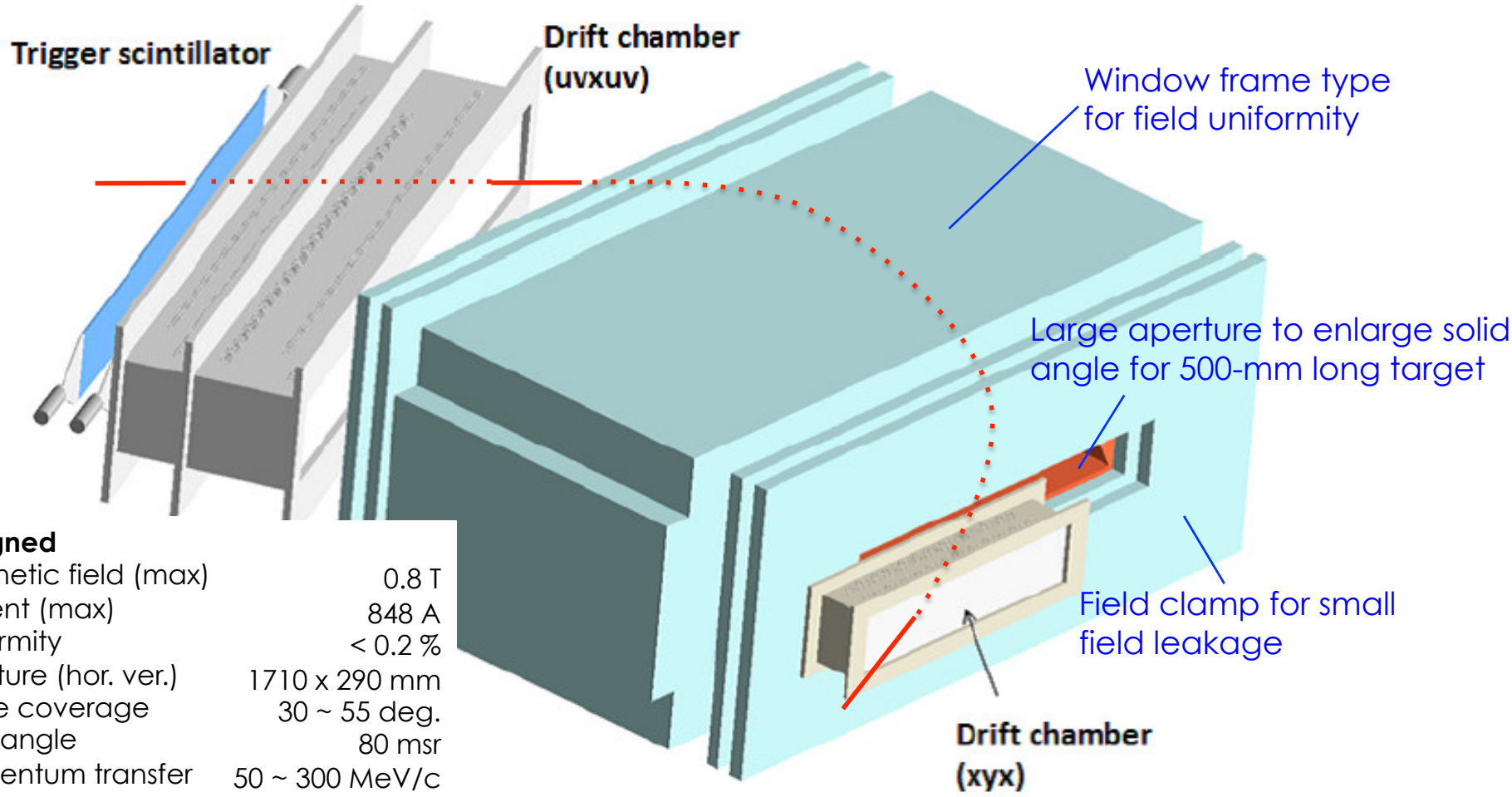
$$L = \frac{N}{t_{meas.}\,\sigma_{brems.}\,\varepsilon_{det.}}$$





Window-frame type SCRIT Electron Spectrometer (WiSES)

in combination with drift chambers and trigger scintillators



Designed	
Magnetic field (max)	0.8 T
Current (max)	848 A
Uniformity	< 0.2 %
Aperture (hor. ver.)	1710 x 290 mm
Angle coverage	30 ~ 55 deg.
Solid angle	80 msr
Momentum transfer	50 ~ 300 MeV/c
Electron energy	100 ~ 300 MeV

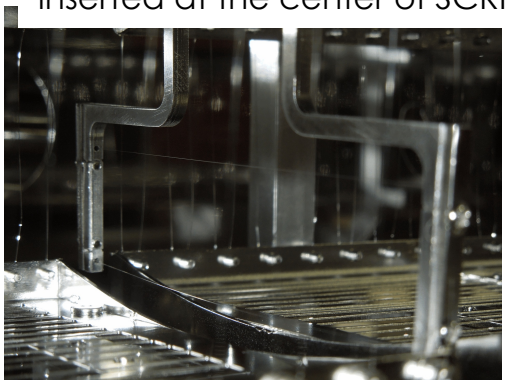
Momentum resolution 0.1 % (300keV/c at 300MeV)

Performance of WiSES

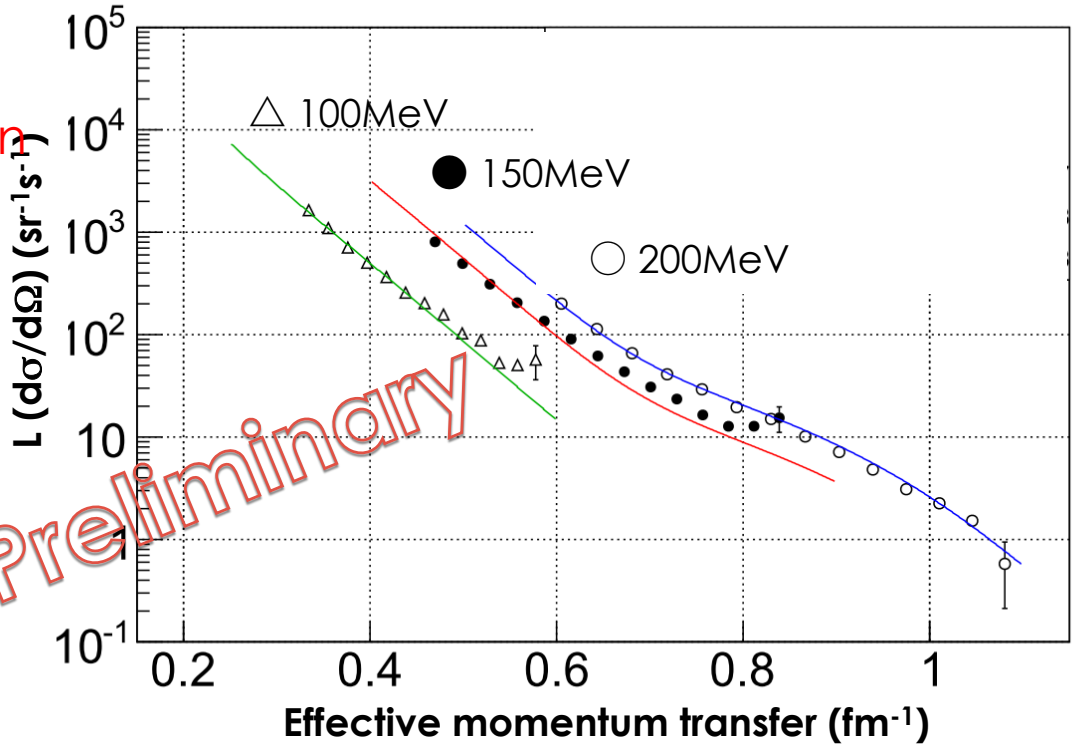
Measurement of elastic scattering from W wire target
with **luminosity ~10^{28} /(cm^2s)**

Studies for evaluating :
- momentum resolution
  - ⟹ ~2.5x10^{-3} at 300MeV
- vertex resolution
  - ⟹ 2~3mm/z, 4mm/y
- acceptance distribution,
  - ⟹ well agree with simulation
- and the other characteristics

W-wire target
inserted at the center of SCRIT

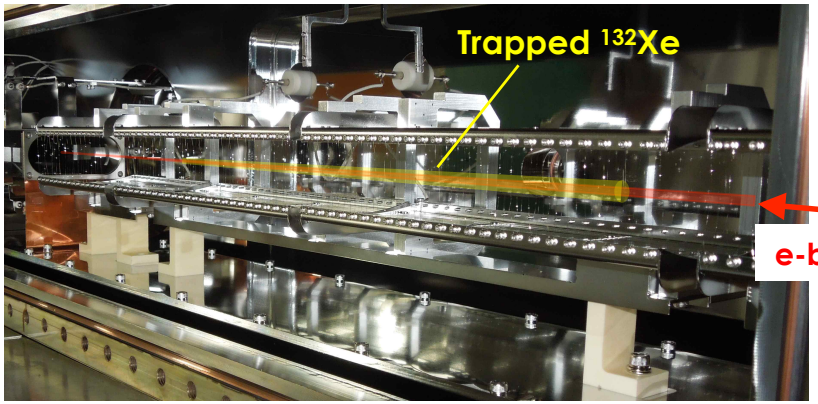


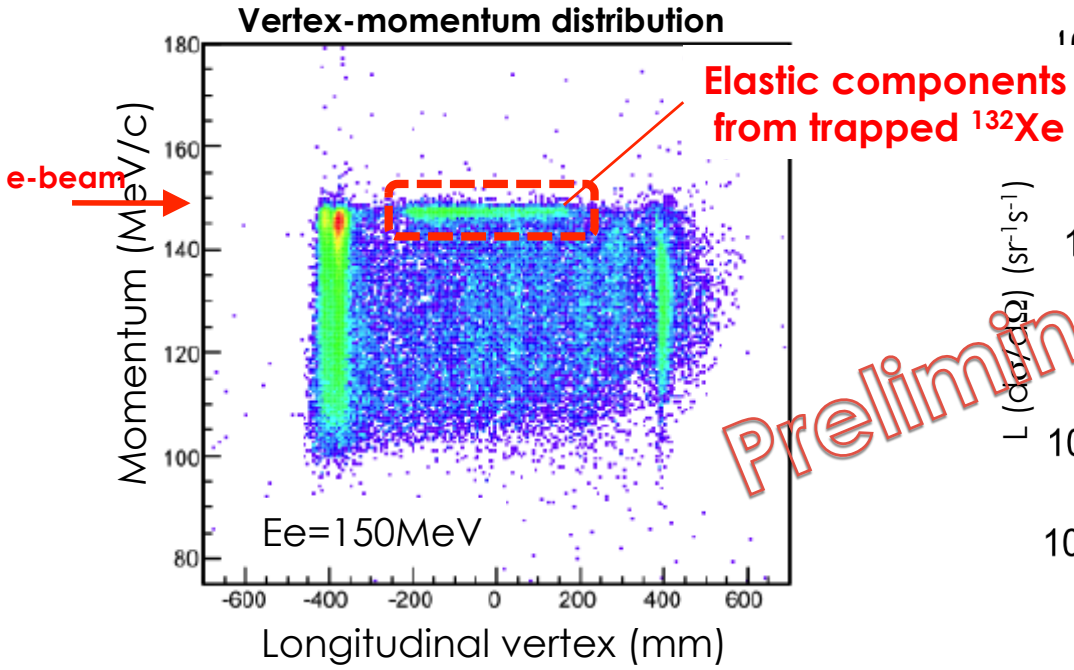
Wide range of momentum transfer is covered by changing electron beam energy.

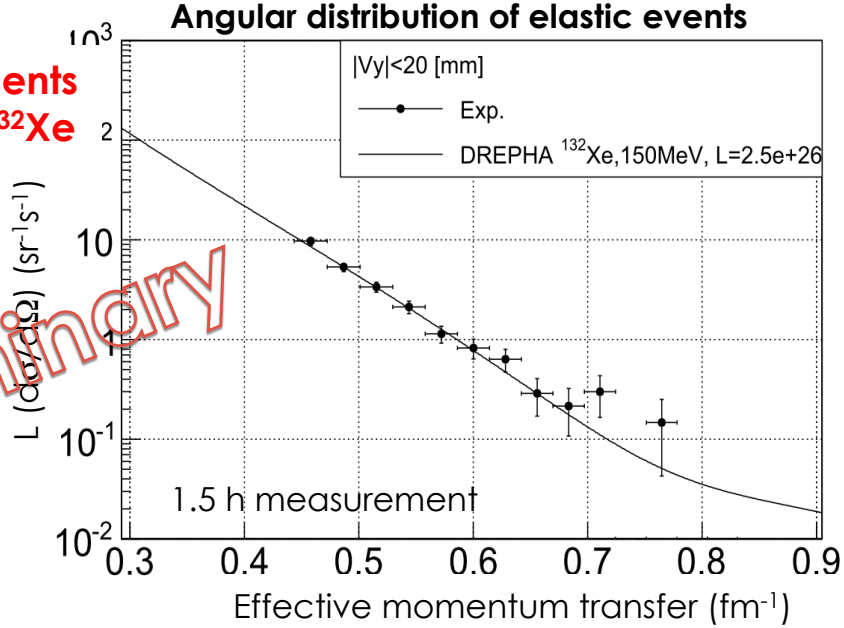


Performance of WiSES

Elastic scattering from trapped ^{132}Xe ion with the luminosity 2.5x10^{26} /(cm^{2}s)







Preliminary

Summary

- SCRIT facility construction has been almost completed.
- The facility is now under comprehensive test.
- Works in progress are :
  - bug hunting in all system
  - improvement of RI beam extraction efficiency at ERIS
  - improvement of CD-Pulse conversion efficiency at buncher
  - RTM beam power upgrade
  - study of detector characteristics of WiSES
- In this fiscal year :
  - elastic scattering cross section measurement for Xe isotopes
  - experiments for RI will be started.

Thank you for your attention