短寿命不安定核との電子弾性散乱

ー”不可能”と考えられていた電子散乱実験ー

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- 短寿命不安定核の電子散乱実験方法の確立
- e-RI facility @ RIBF

electron scattering

- point particle
- electromagnetic interaction
  - exp. data -> structure information
  - “weak” -> probing whole volume
  - cross section -> not large
- Fourier mapping of a specific transition amplitude

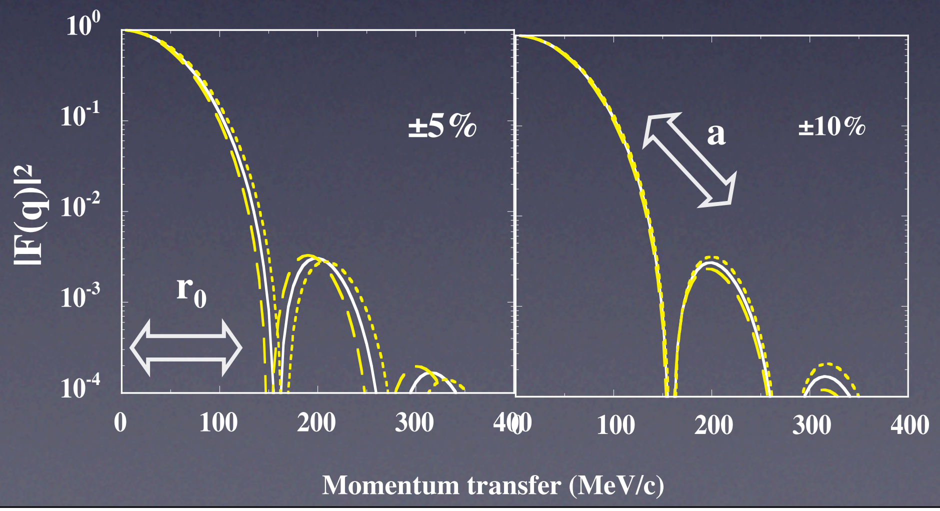
elastic scattering

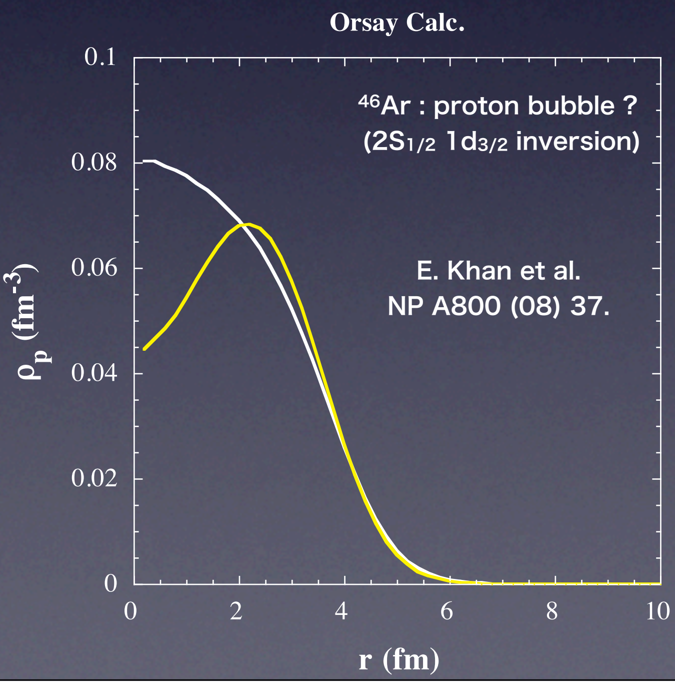
- charge density distribution => beyond $\langle r_c^2 \rangle^{1/2}$
- largest cross section (up to medium q region)

spinless nucleus

$$\frac{d\sigma}{d\Omega} = z^2 \sigma_{Mott} |F_c(\vec{q})|^2$$

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





Required luminosity for e-RI scattering experiments

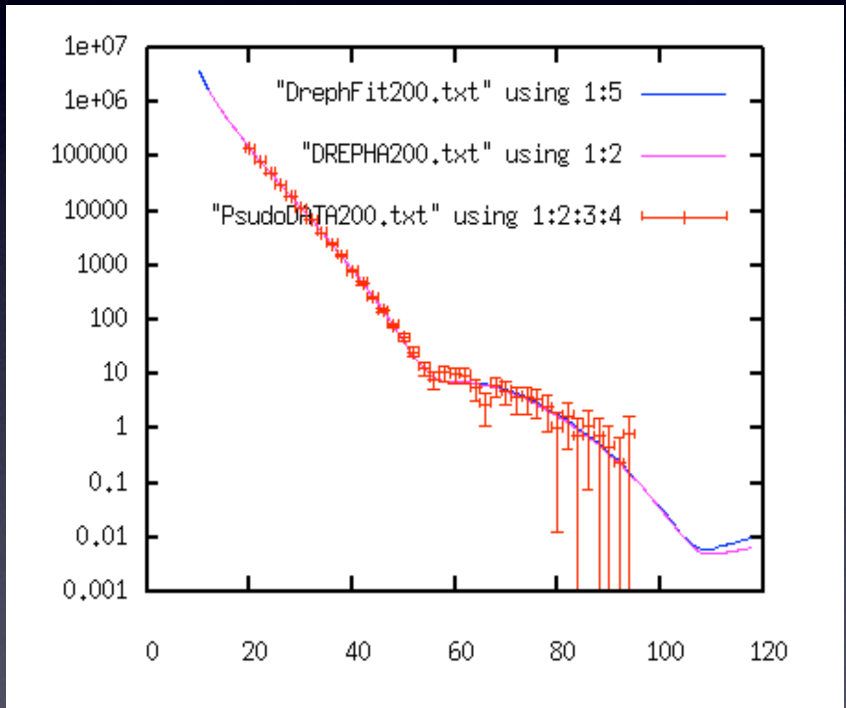
ex. elastic scattering for Ni, Sn isotopes

$L = 10^{26}$ /cm^2/s

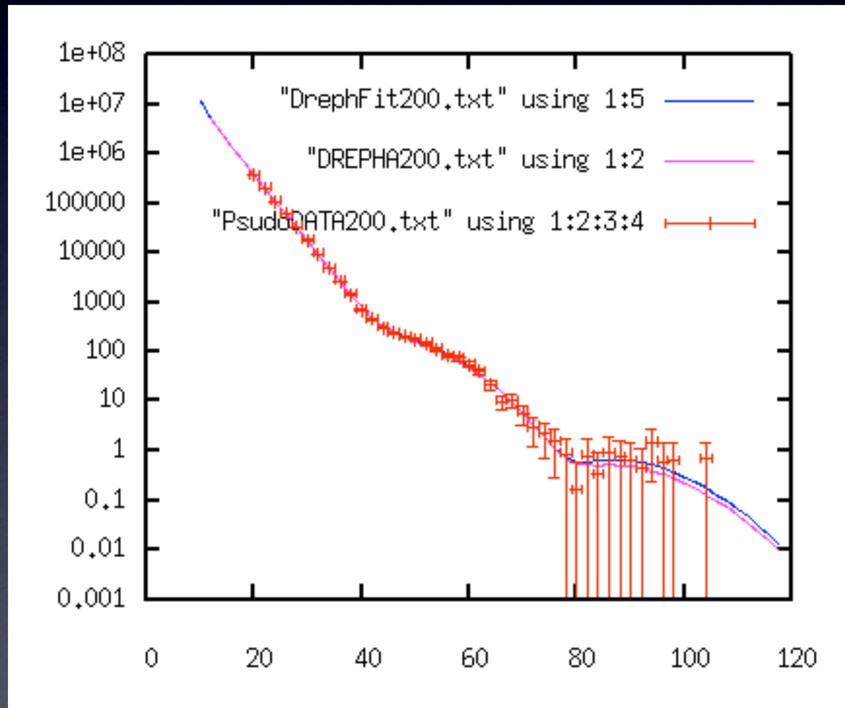
Ee = 200 MeV 1 week

$\Delta\theta$ = 1 deg. $\Delta\phi$ = 90 deg.

Ni



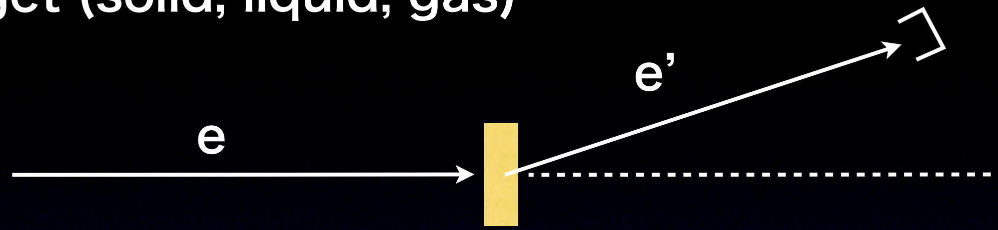
Sn



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

electron scattering experiments

fixed target (solid, liquid, gas)



not possible for rarely-produced short-lived nuclei

e-RI collider

ELIse@FAIR
Ee ~ a few 100 MeV

RI at rest

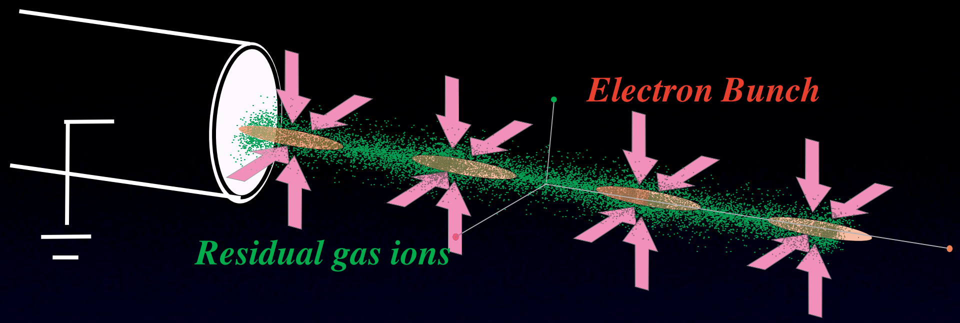
SCRIT@RIBF
Ee ~ a few 100 MeV

electron at rest

γ_{RI}~ a few 100 (!)

What is SCRIT (Self-Confining RI Target) ?

"Ion trapping" phenomena observed at electron rings

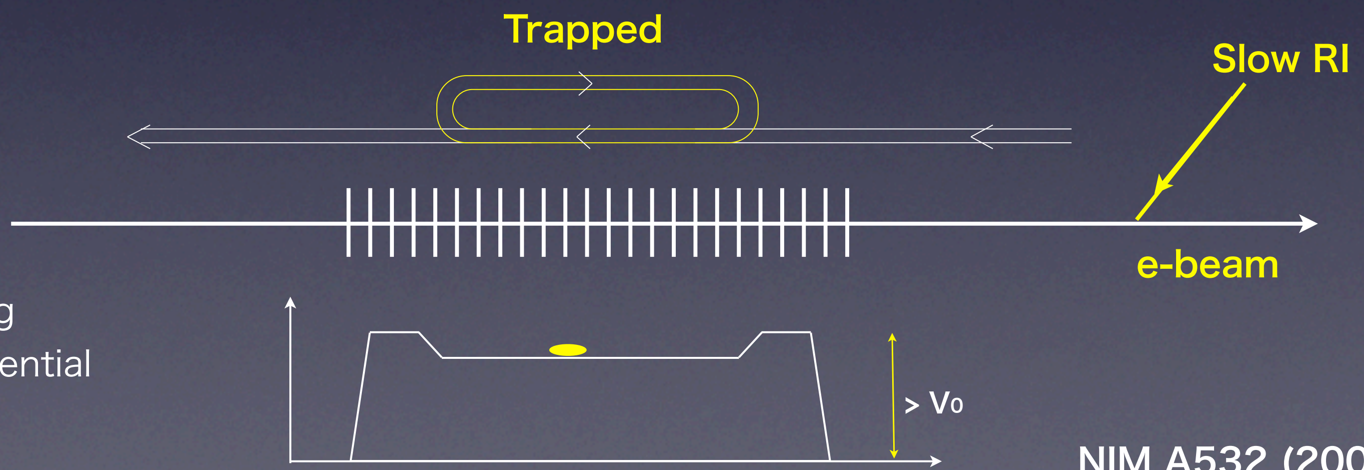


ionized residual gases by electrons

are trapped by electron beam itself.

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

electron scattering !!



transverse : ion trapping

longitudinal : mirror potential

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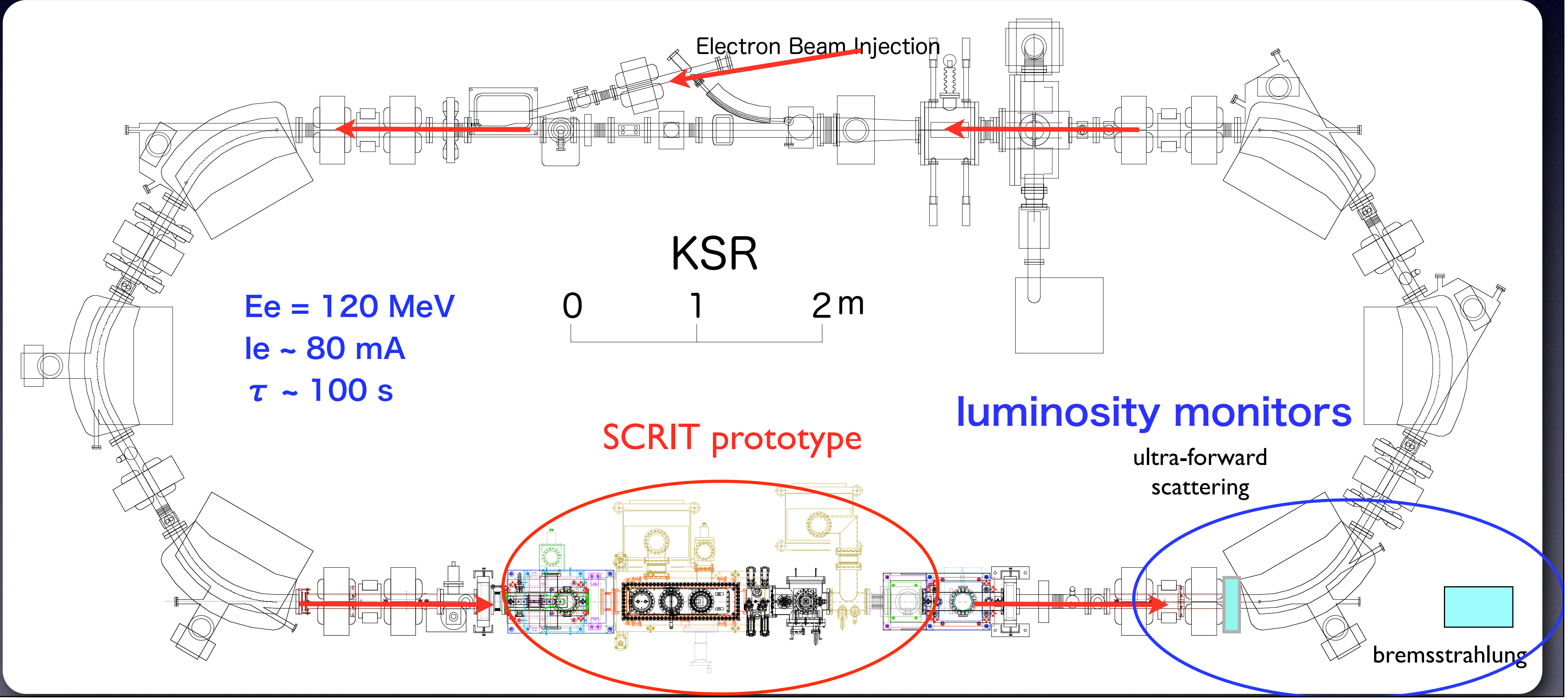
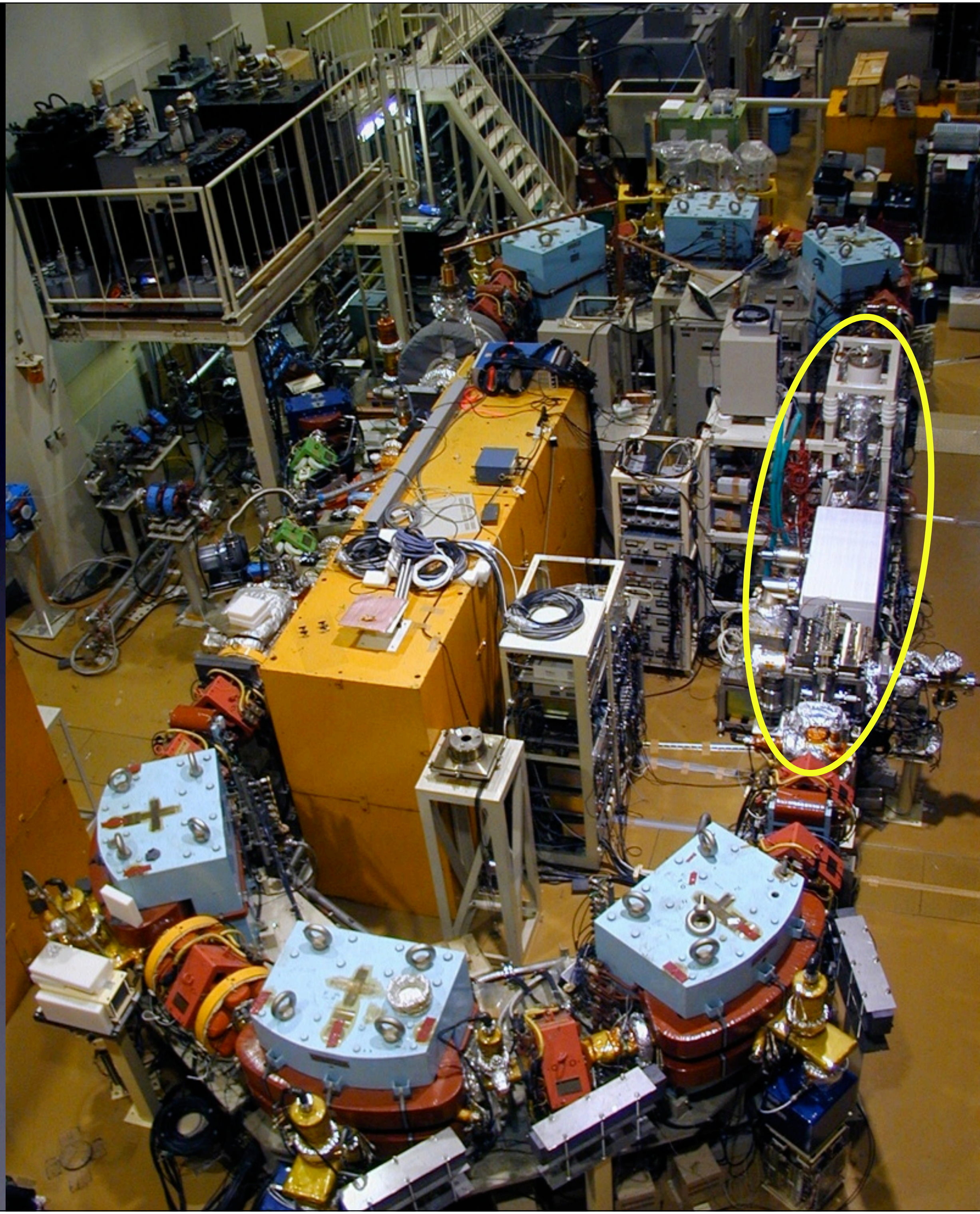
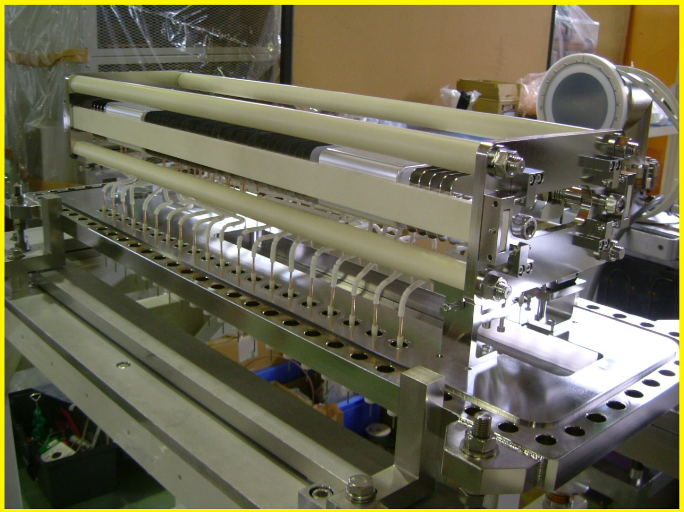
R&D studies at KSR, Kyoto Univ.

- externally injected ions are really trapped ?
- high enough luminosity achievable ?
- number of ions required to achieve the target luminosity

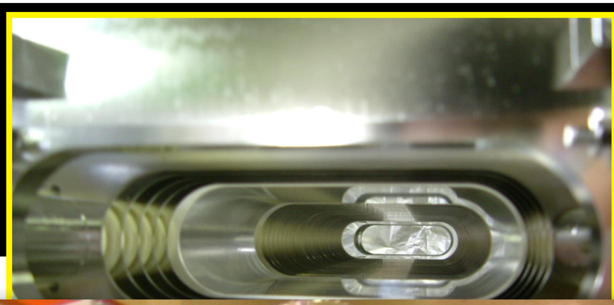
- luminosity monitors
  - bremsstrahlung : $\sigma \sim 40$ b ($E_\gamma \geq 20$ MeV)
  - ultra-forward elastic scattering : $d\sigma/d\Omega^* \Delta\Omega \sim 300$ b ($\theta \sim 15$mrad)

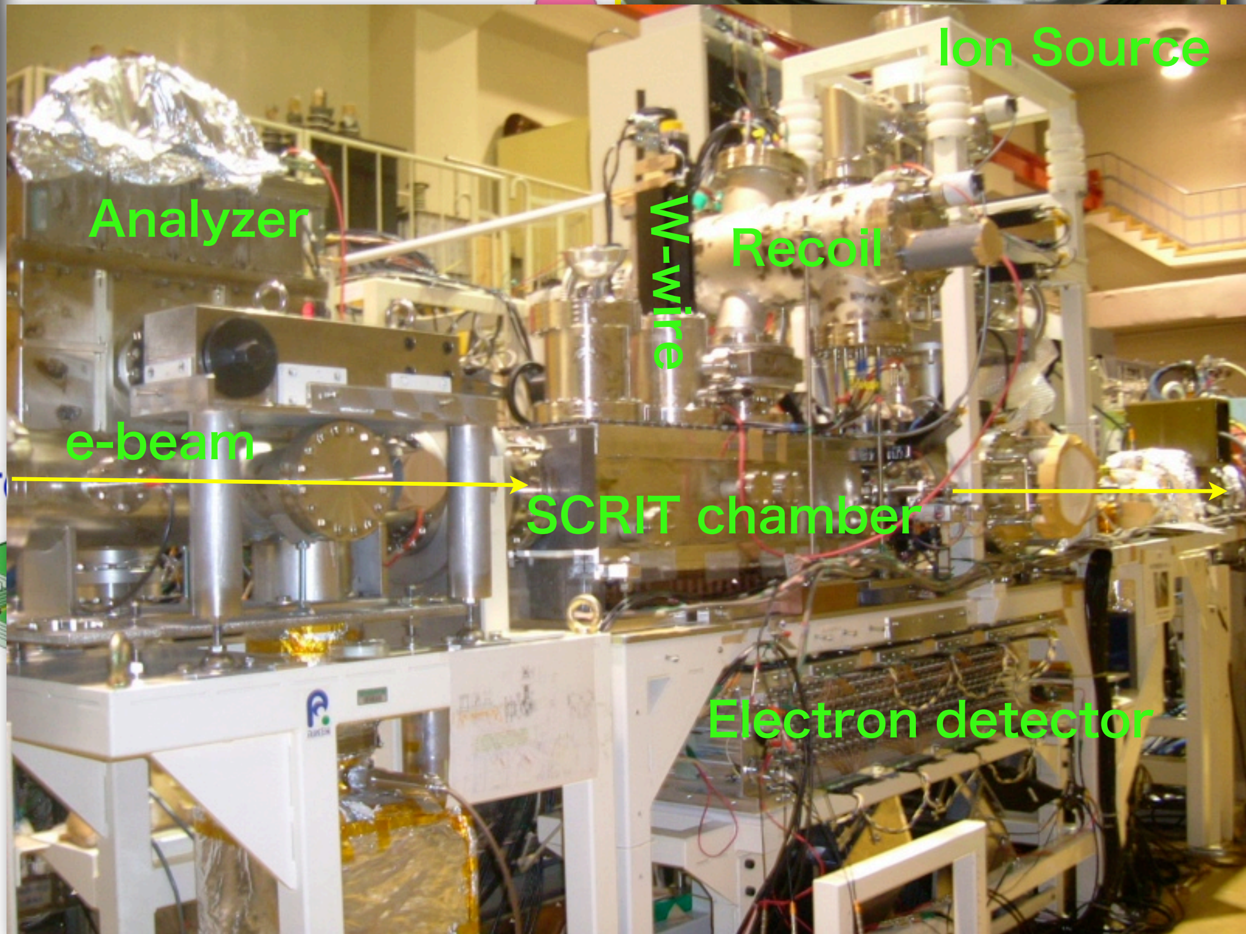


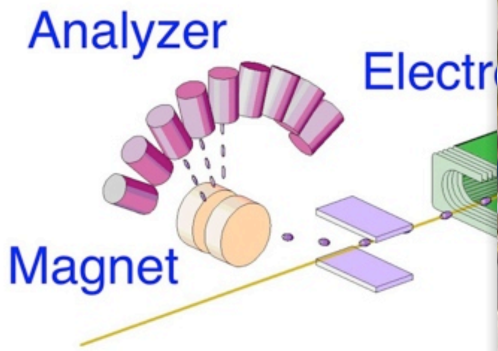




installed at KSR,

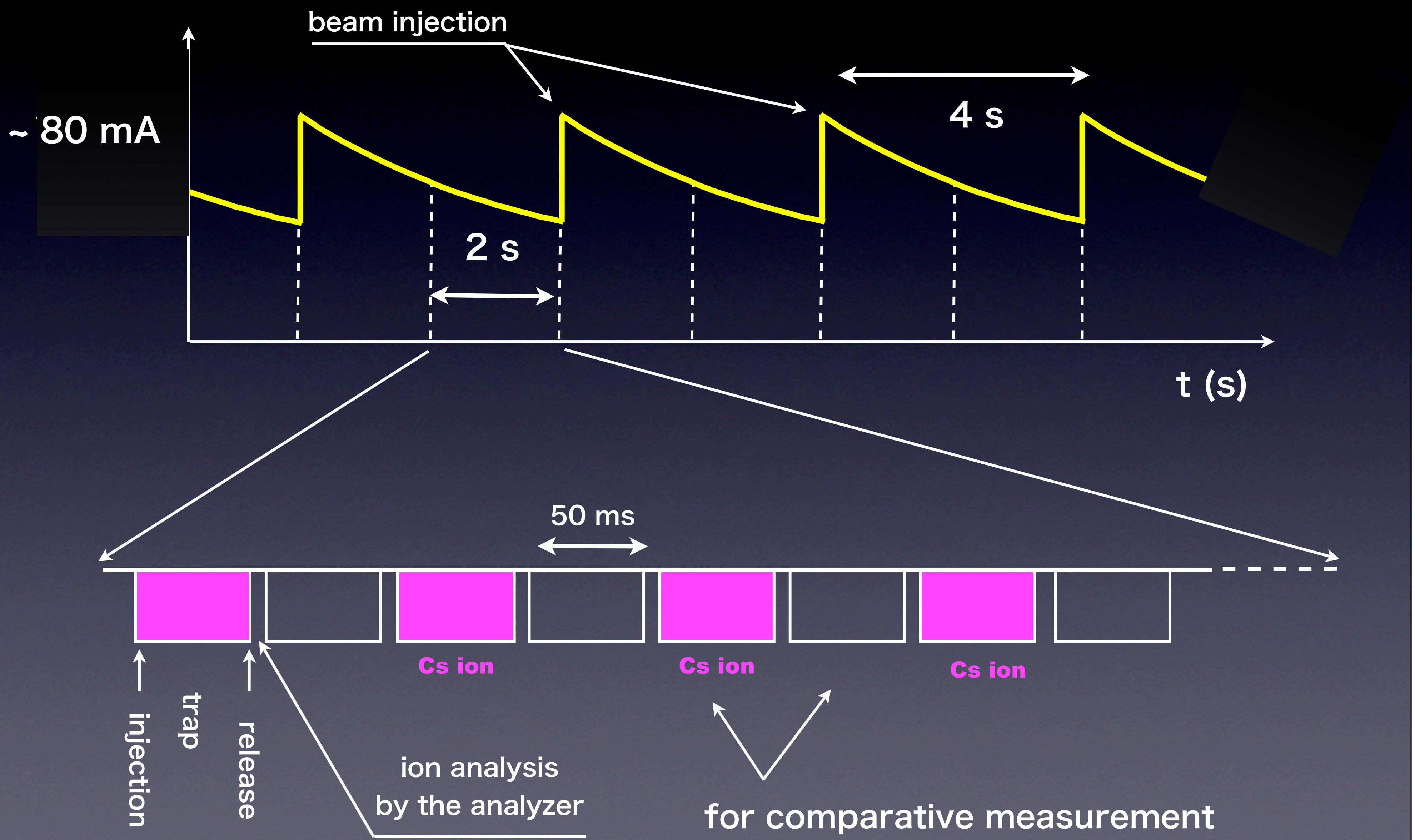




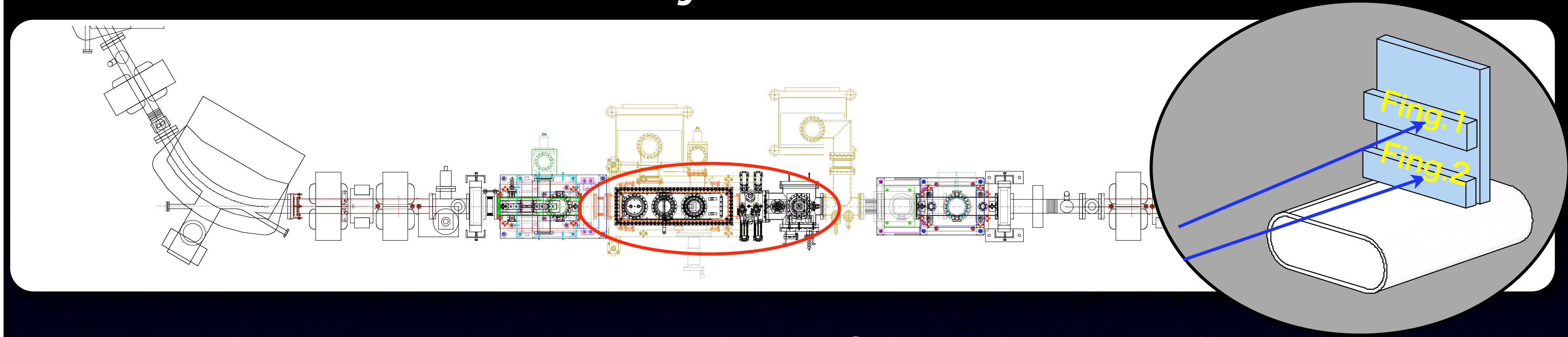


Time sequence of the measurement

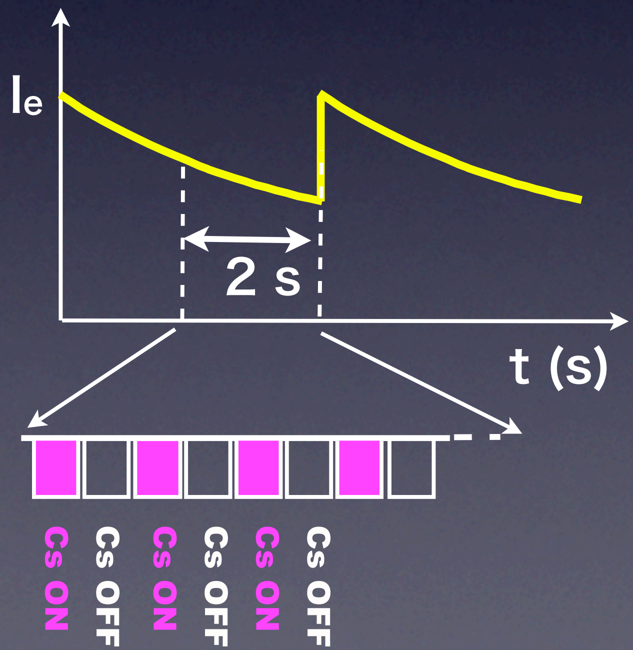
beam lifetime of KSR τ~100 s @ 80 mA

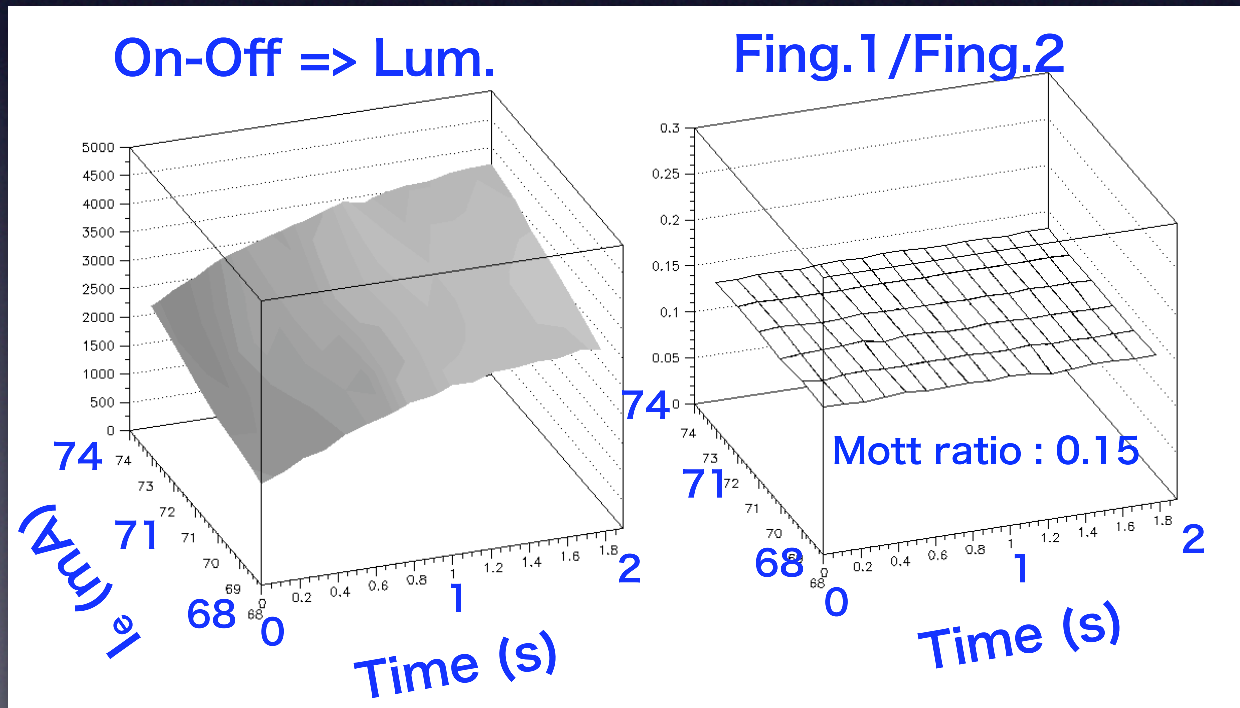


Luminosity monitors

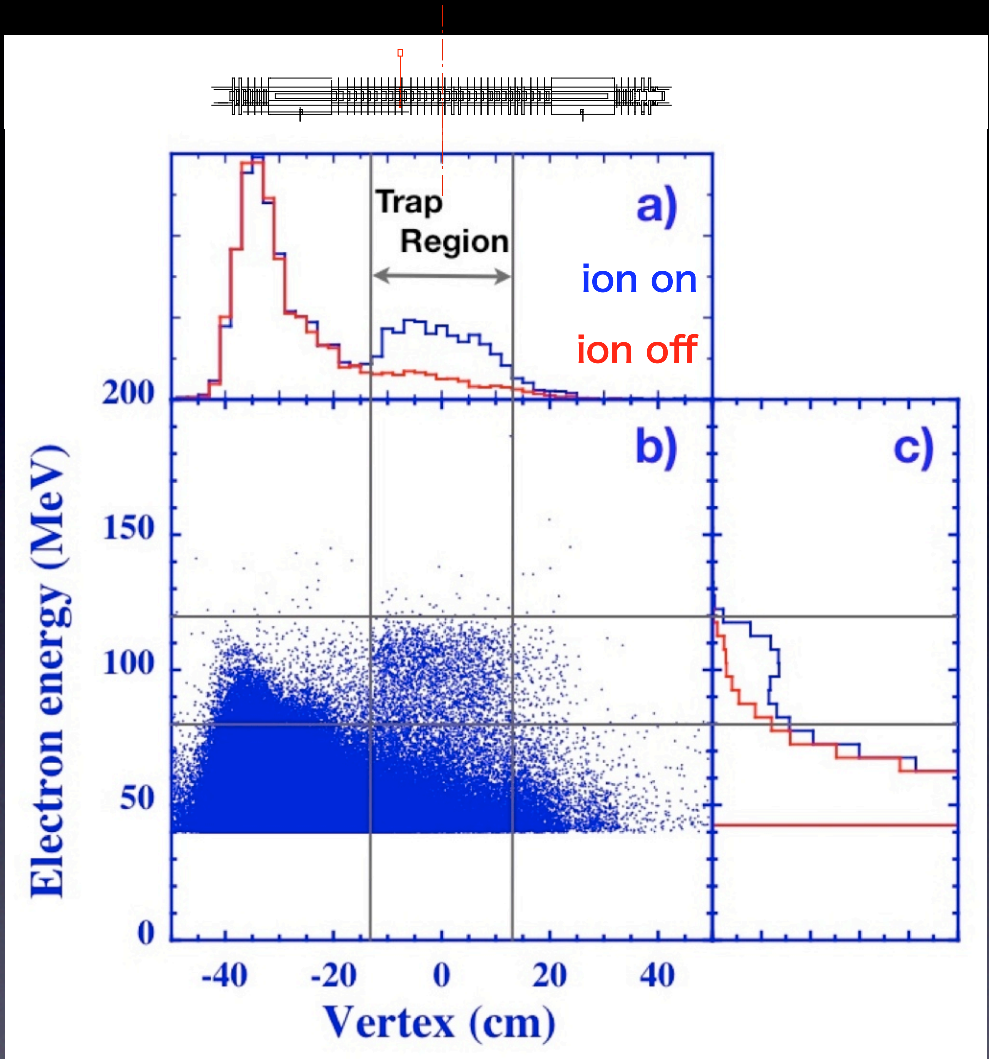


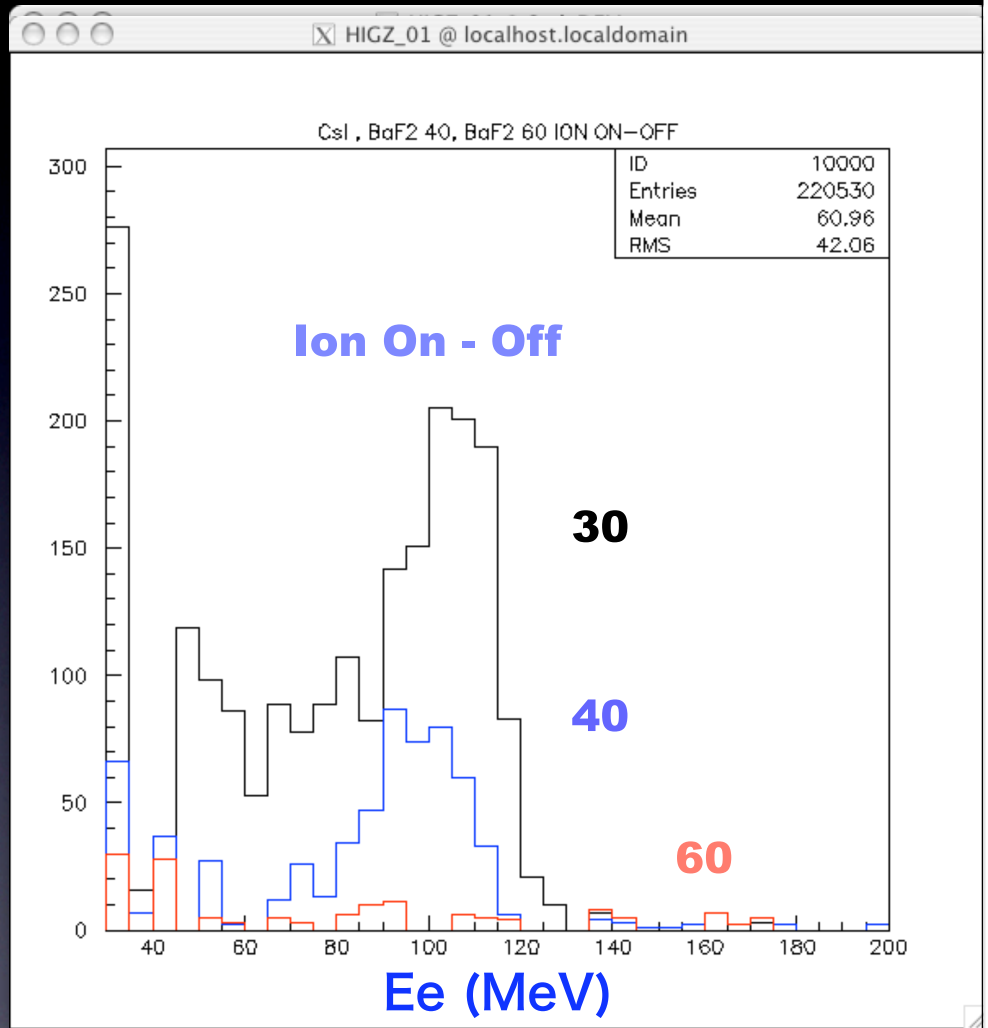
utilizing scattered electrons at ultra-forward angle : ~ 1kHz





electron scattered from the trapped Cs ions



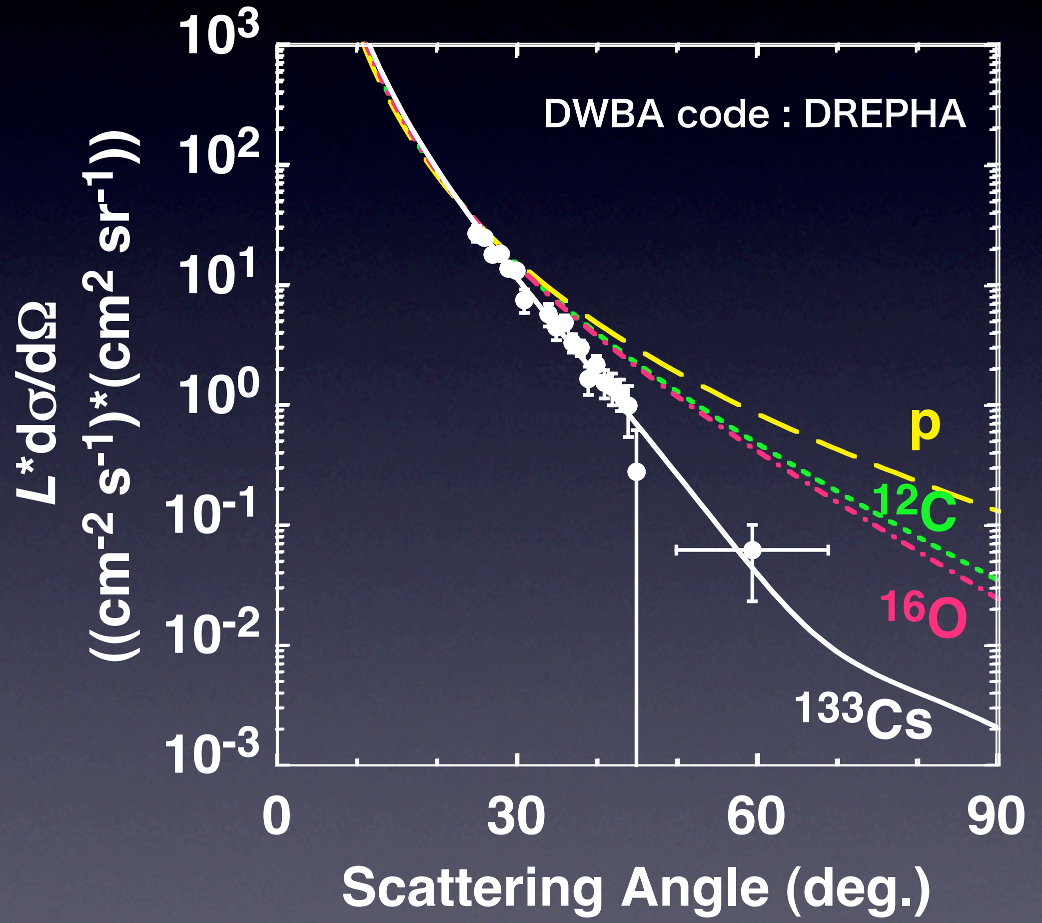


Consistent with the response
of pure CsI to 120 MeV electrons

Angular distribution of elastic events

PRL 100 (2008) 164801
PRL accepted

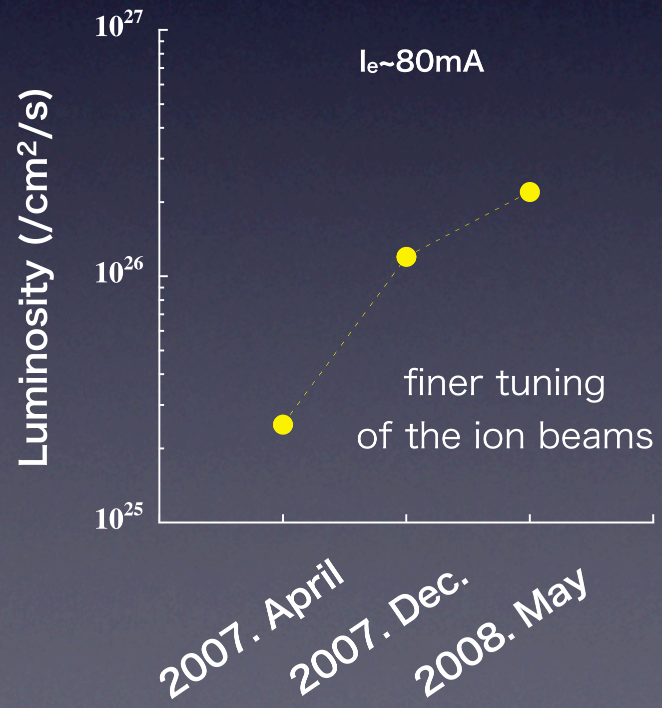
$$N(\theta) = \left(L\frac{d\sigma}{d\Omega}\right) T \int dv \Delta\Omega(\theta, v)$$



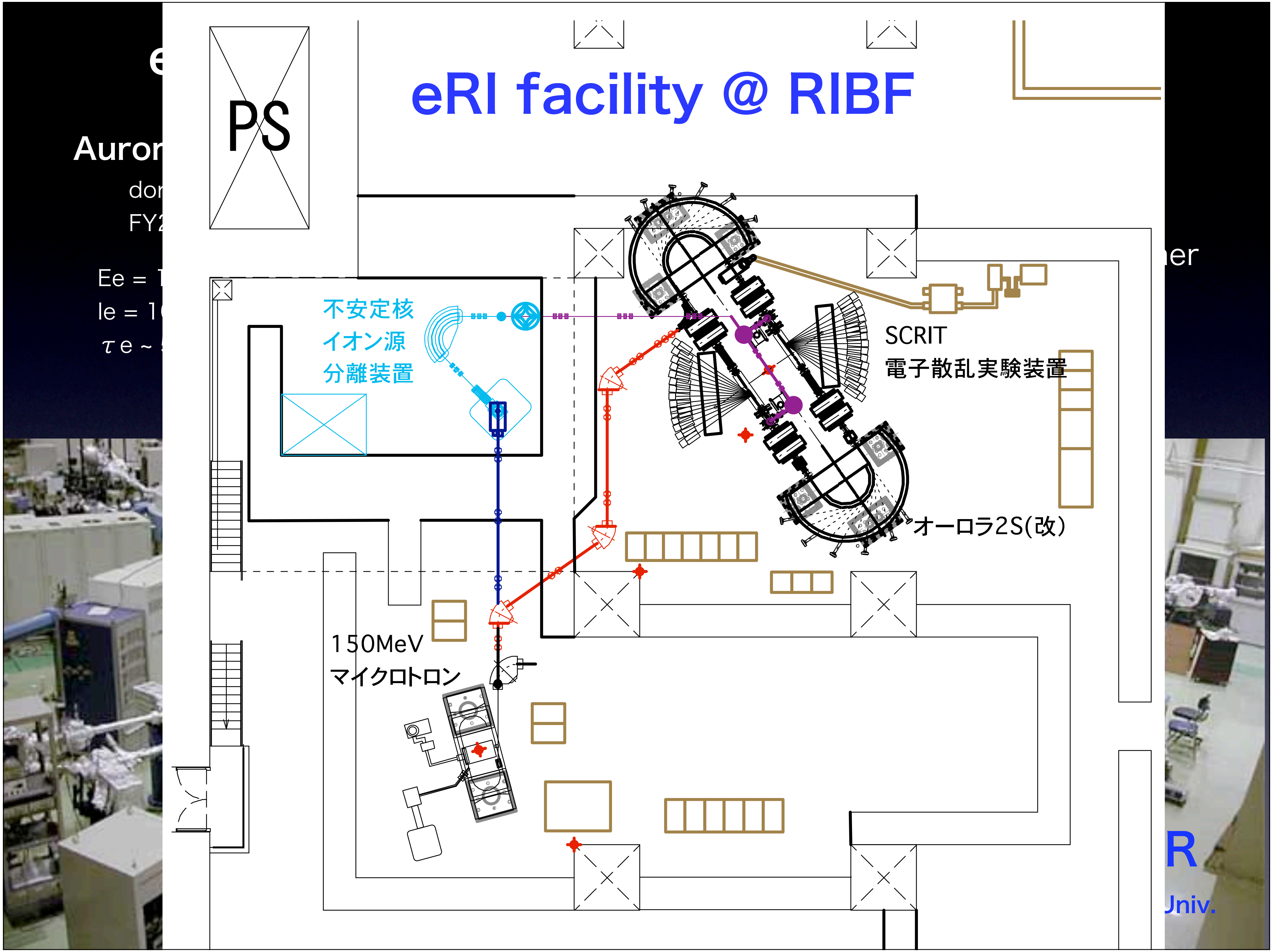
$L=1.2 \times 10^{26}$ /cm²/s
@ I_e = 80 mA (Ne=5×10^{17} /s)

Ne=5×10^{17} /s (I_e = 80 mA)
Nt (/cm²) = L(/cm²/s) / Ne (/s)
= 2.4×10^{8} /cm²

N_{ion}*(on e-beam)* ~ 10^6



eRI facility @ RIBF

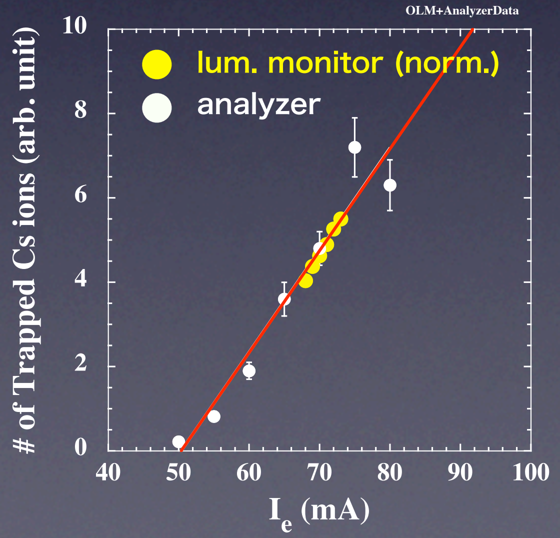


e-RI facility @ RIBF

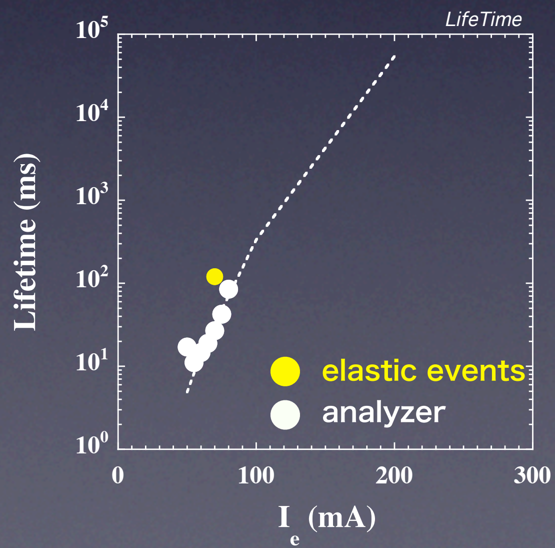
	KSR (120 MeV)	AURORA (≥ 200 MeV)	AURORA/KSR
I_e (mA)	80	≥ 300	4
N_{ion}	1	> 10	>10
τ_{ion} (ms)	120	∞ (計算)	

1) At least, ~10^2 larger luminosity will be easily achievable.
2) longer measuring time (typically 1 week <==> 5 hours KSR) ~10
3) lower-emittance ion beam, better ion manipulation ... x 10^{α}

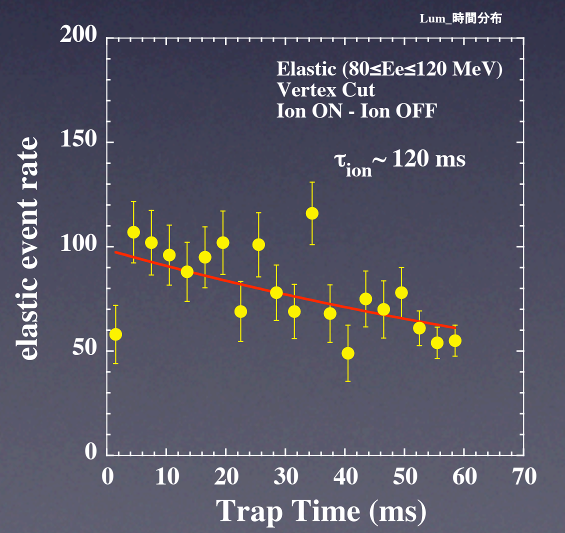
N_{ion}(trapped) vs. Ie



τ_{ion} vs. Ie



elastic event rate in 50ms



Summary

SCRIT R&D @ KSR

- externally injected ions are really trapped ?
- high enough luminosity achievable ? : $\geq 10^{26}$/cm^2/s @ 80 mA
- number of ions required to achieve the target luminosity $10^{6\text{-}7}$ /s @ KSR R&D
- luminosity monitors
  - bremsstrahlung : σ ~ 40 b ($E_\gamma \geq$ 20 MeV) ×
  - ultra-forward elastic scattering : $d\sigma/d\Omega^*\Delta\Omega$~300 b ($\theta$~15mrad)

e-RI facility @ RIBF

Electron beam

electron ring (AURORA) (Sumitomo donation + FY2008 Suppl. budget)

operation starts in 2009

E_e = 200 -300 MeV, $I_e \geq$ 300 mA, τ_e ~ a few 100 min

Slow RI beams (the next R&D issue)

fragment separator + gas chacther

ISOL based on e (γ) + U fission : development