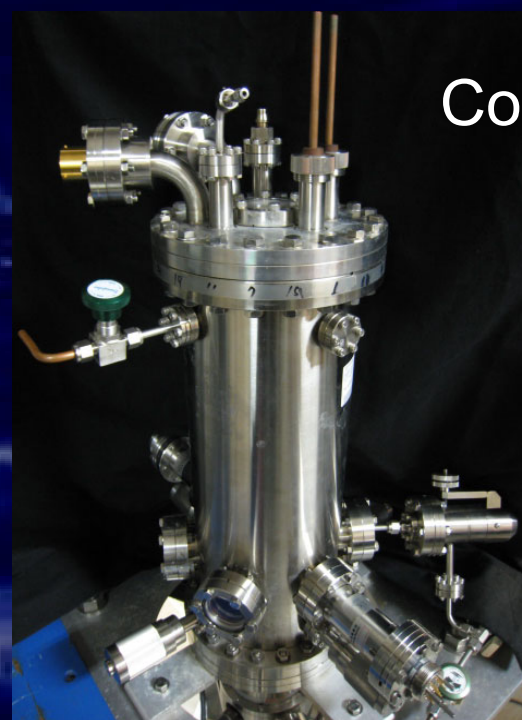


電子ビームイオントラップによる 鉄・タングステン多価イオンの分光計測



Tokyo-EBIT



CoBIT

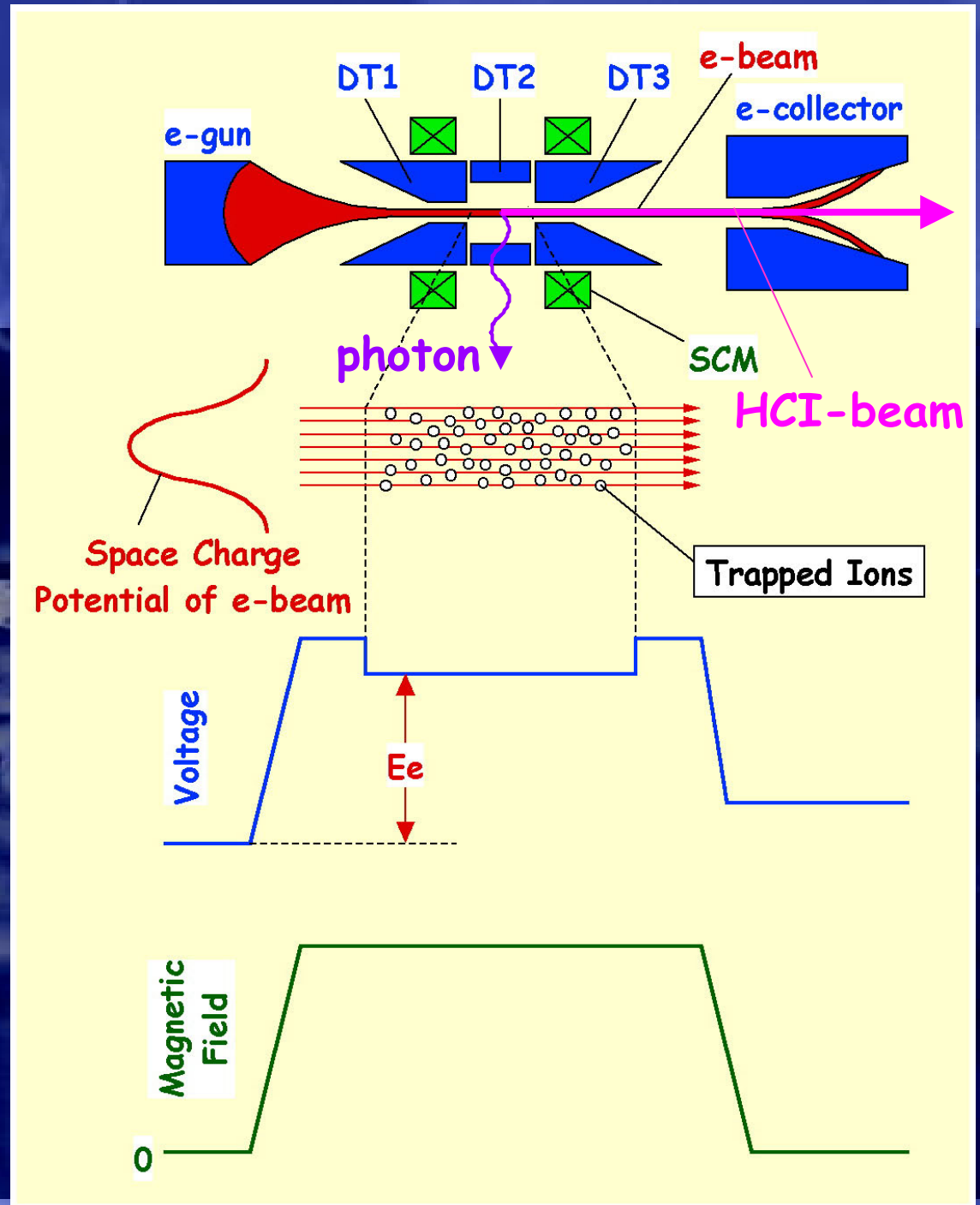
中村信行 (電気通信大学レーザー新世代研究センター)
2008/12/18 原子分子データ応用フォーラムセミナー@NIFS

電子ビームイオントラップ Electron Beam Ion Trap (EBIT)

- あらゆる多価イオンに関する広範なデータ
 - 遷移波長、エネルギー準位
 - 遷移確率（遷移寿命）
 - 偏光度
 - 任意プラズマ中での発光強度
 - 電子衝突断面積（励起、電離、再結合、共鳴、など）
 - 電荷移行断面積
 - 固体表面との相互作用における2次粒子収量

Principle of EBIT (EBIS)

- A high density e-beam compressed by strong B-field ionizes trapped ions successively.
- Axial potential applied to the drift tube and the space charge of the e-beam confine the ions.
- Observation slits at the middle of the drift tube enable spectroscopic studies.
- The trapped ion can be extracted through e-collector as an HCI beam.



EBITの多価イオン光源としての特徴

- 電子ビーム（単色単向）←プラズマ光源との違い
 - ビームエネルギーにより生成価数を制御
 - ビーム電流や磁場により電子密度を制御
 - エネルギー依存、励起関数、共鳴過程
 - 非等方性、偏光度
 - 極細線状光源→スリットレス
- イオントラップ←ビームフォイル分光との違い
 - ドップラーシフトフリー

Tokyo-EBIT

at The Univ. of Electro-Communications

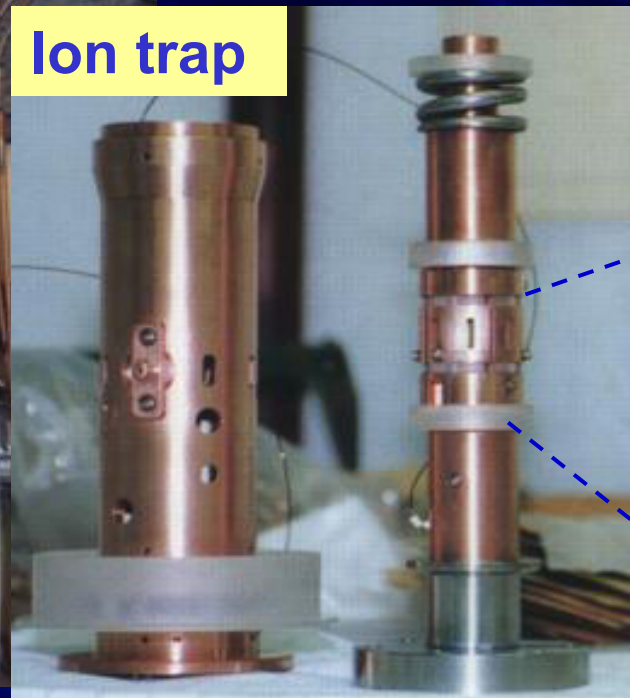
Max. E_e : 200 keV (achieved)

Max. I_e : 330 mA (achieved)

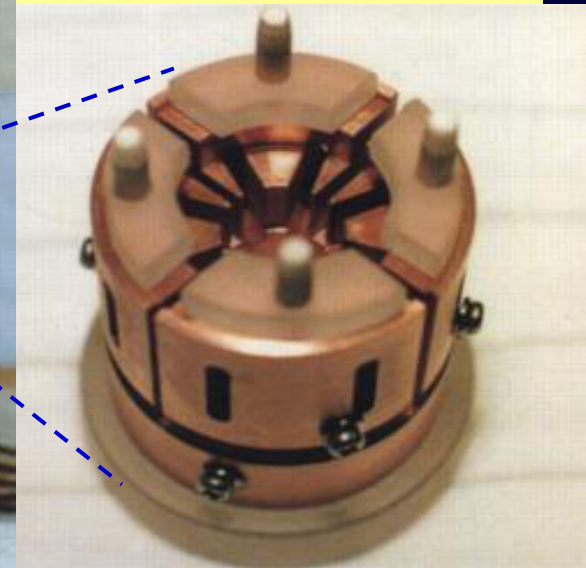
**ANY ion can be produced !!!
(any charge state, any element)**



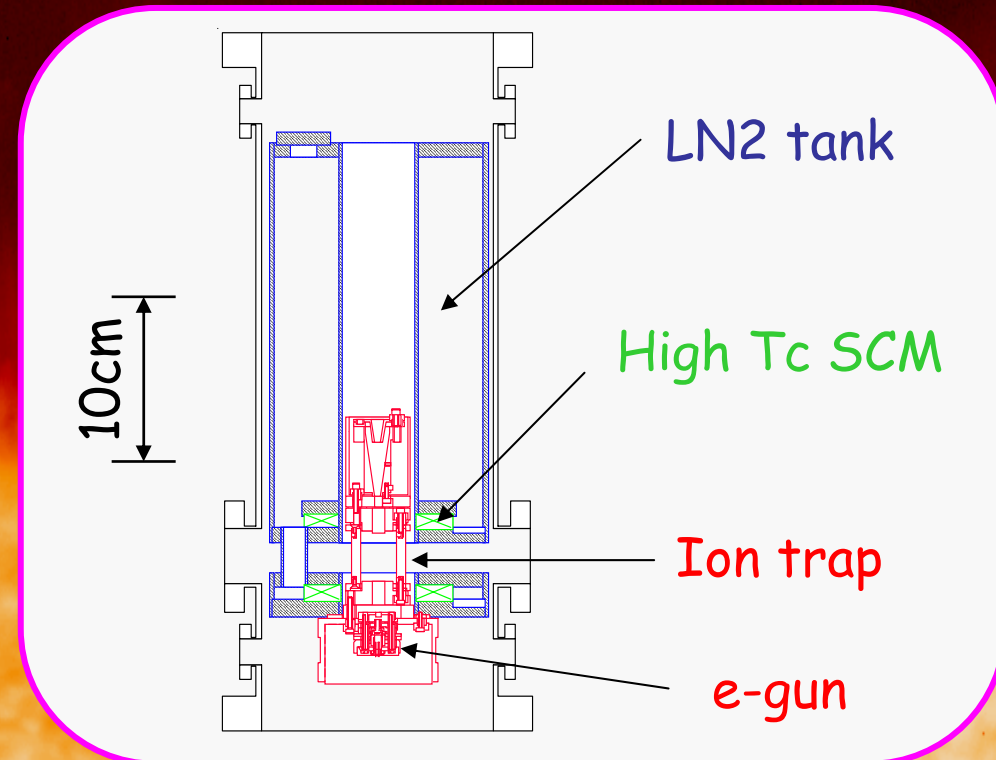
Ion trap



Middle of the trap



CoBIT (Compact, Corona EBIT)



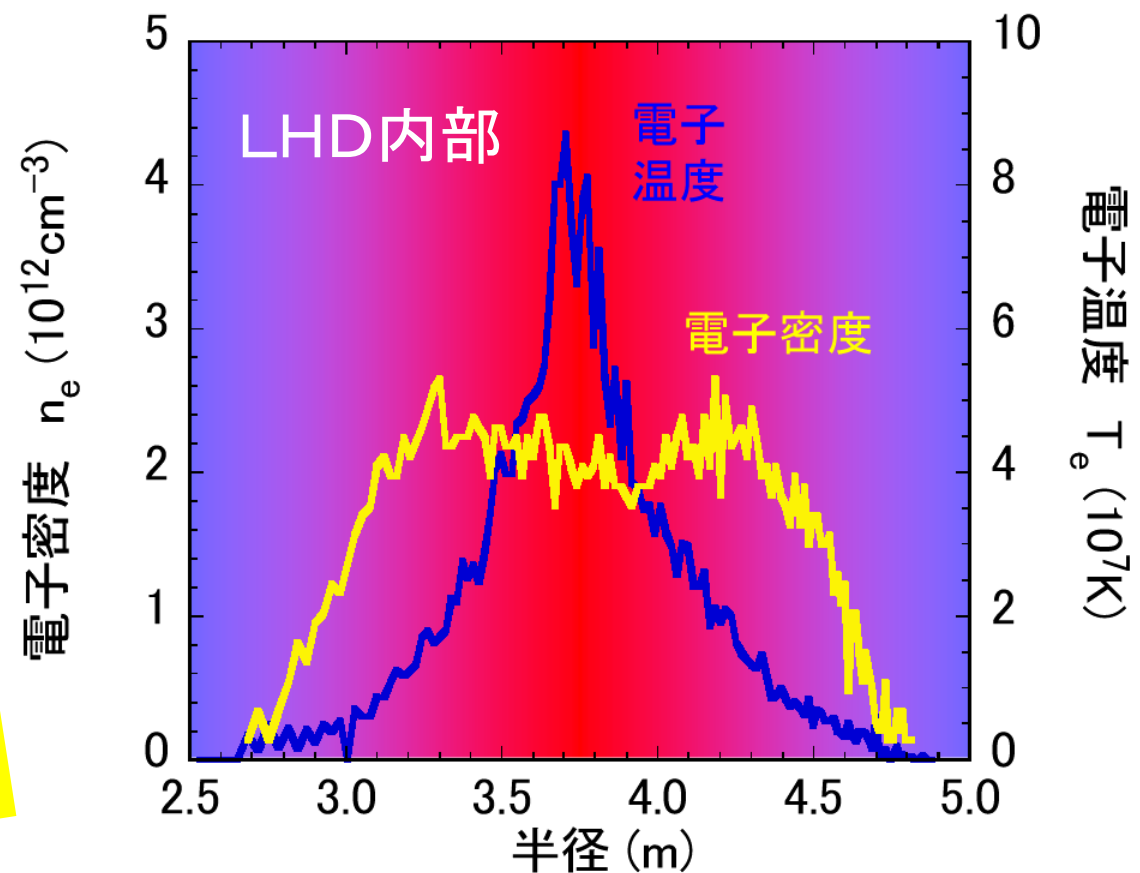
Specifications

e-beam energy	100 – 2500 eV
e-beam current	20 mA (max)
Magnetic field	0.2 T (max)
Temperature	77 K (High-Tc SCM)

EBIT parameters

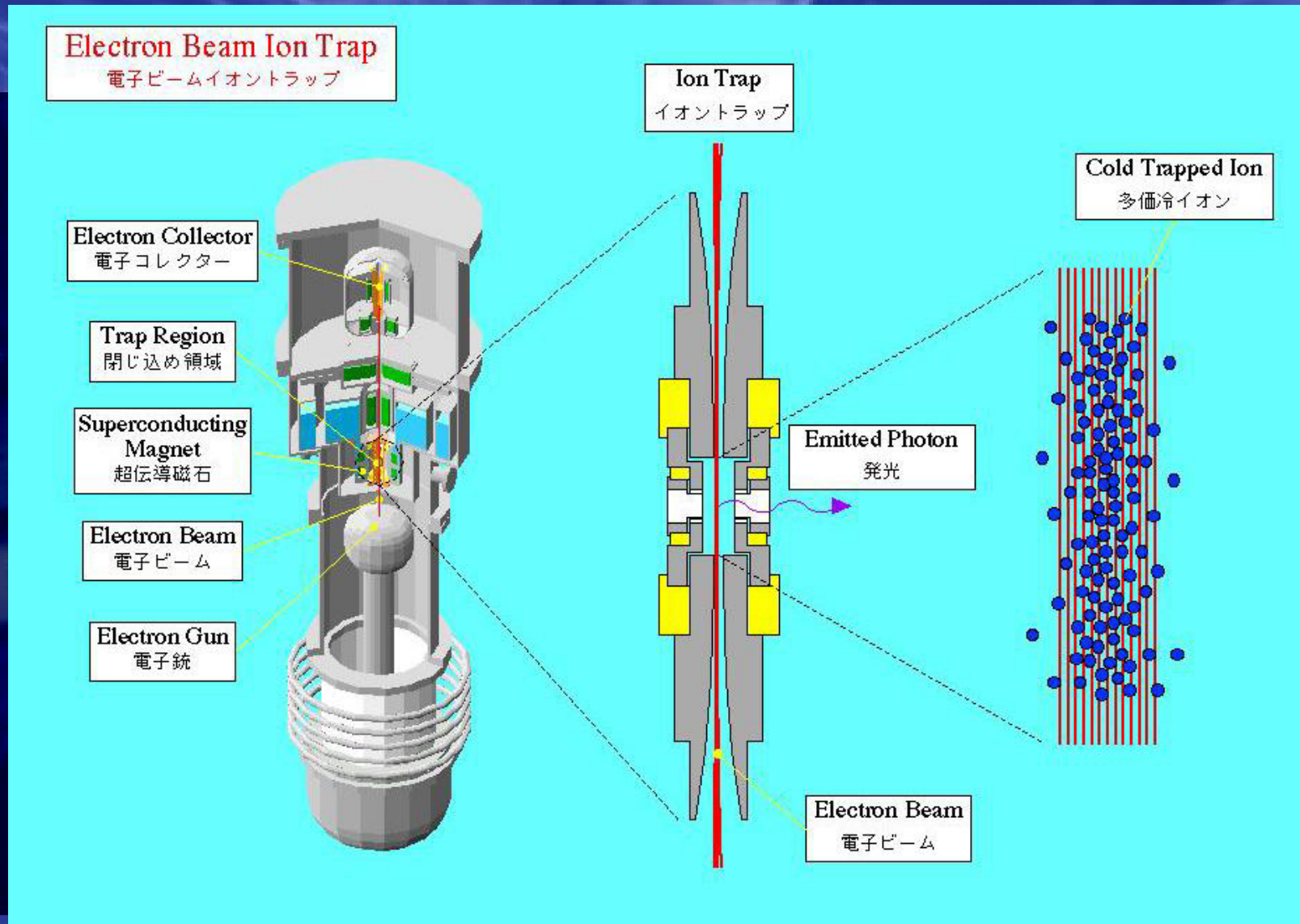
- E_e : 0.1-200 keV
- I_e : 0-300 mA
- Ne: 10^9 - 10^{12} cm^{-3}
- Ni: 10^8 - 10^{10} cm^{-3}
- Ti: 100-1000 eV

高温低密度プラズマの
原子データ取得に最適！

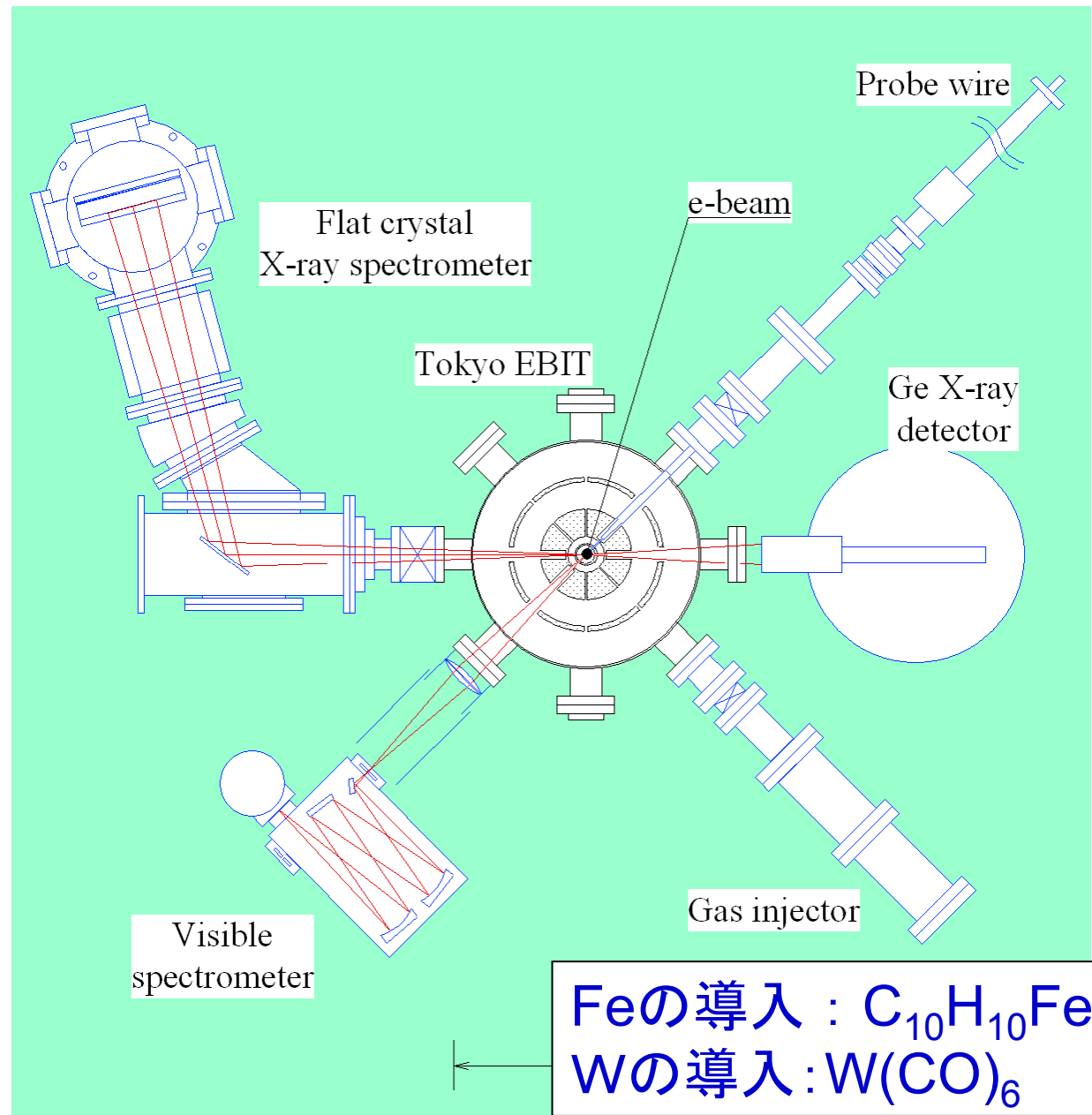


Electron Beam Ion Trap (EBIT)

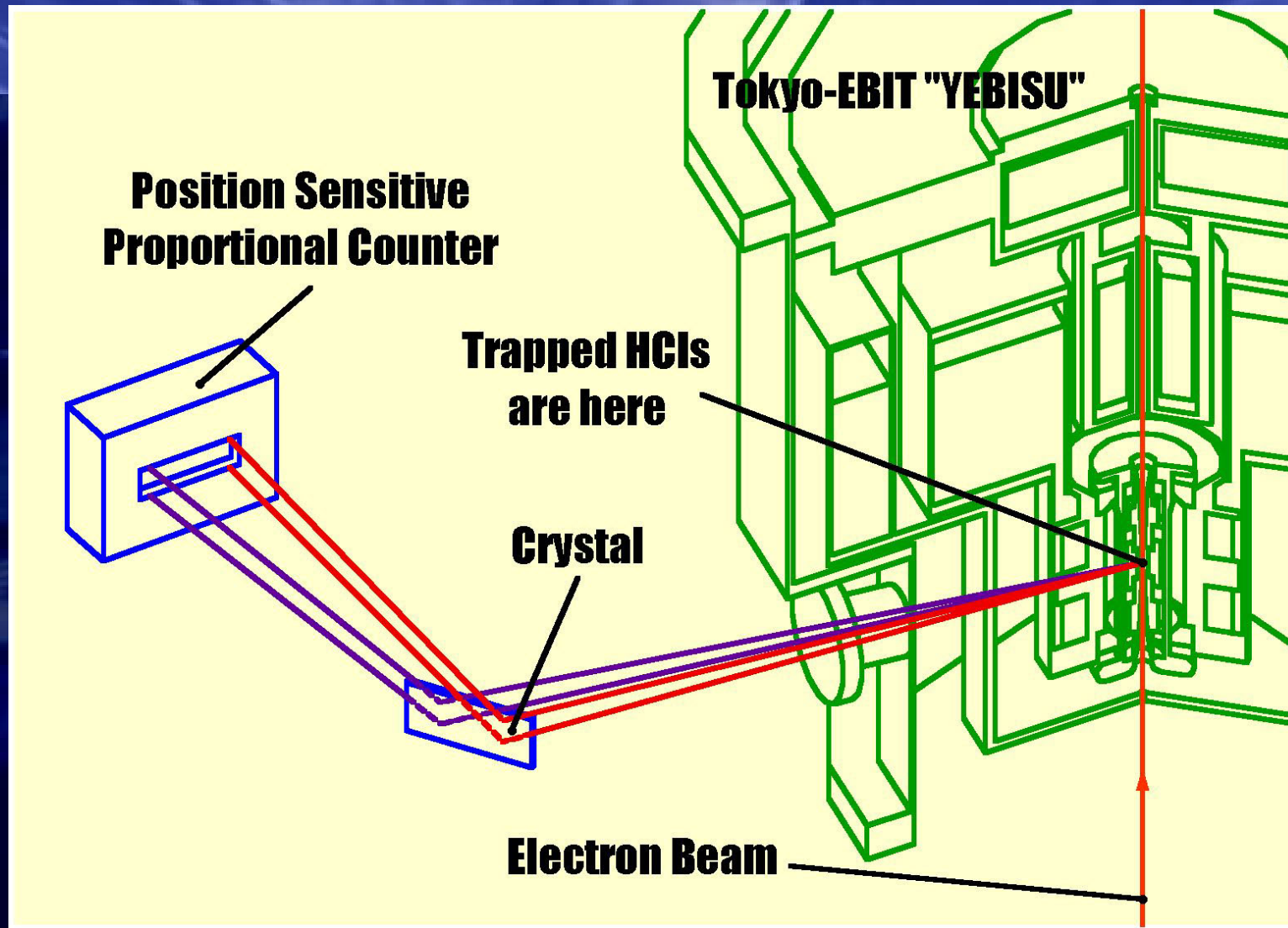
- device for producing and trapping highly charged ions -



観測装置 配置図

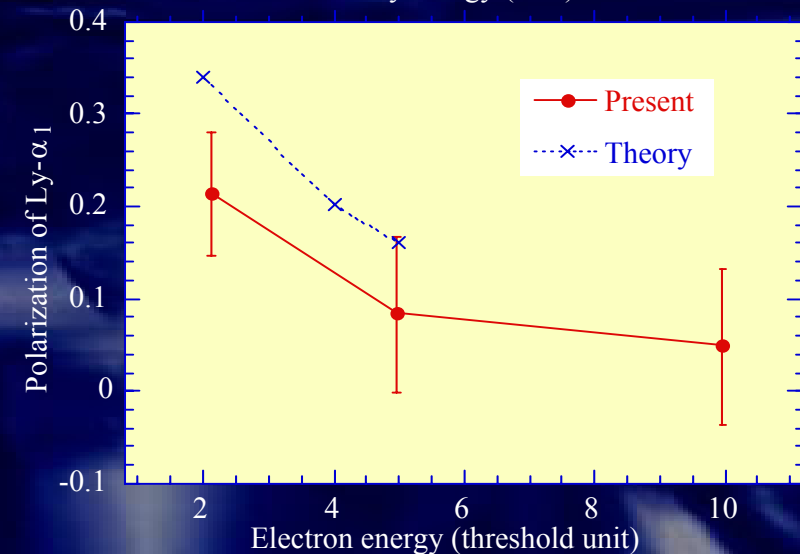
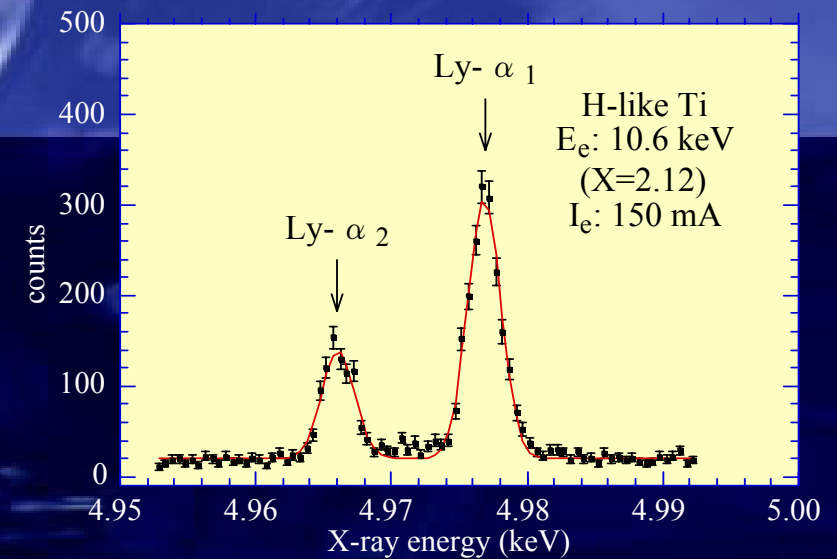


X線結晶分光器



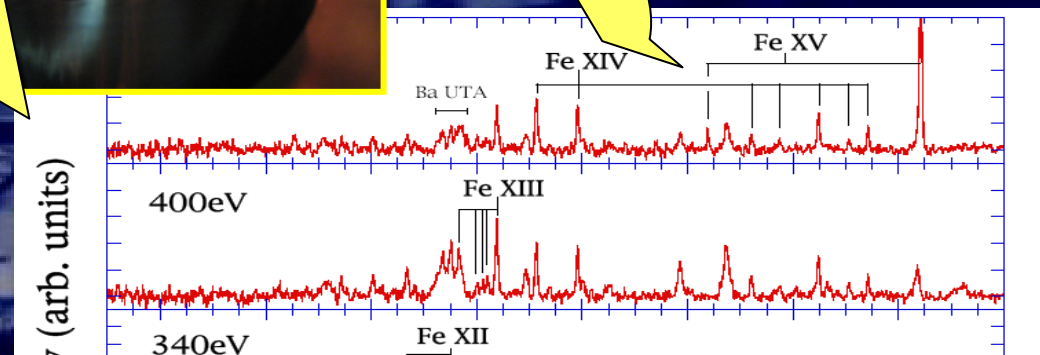
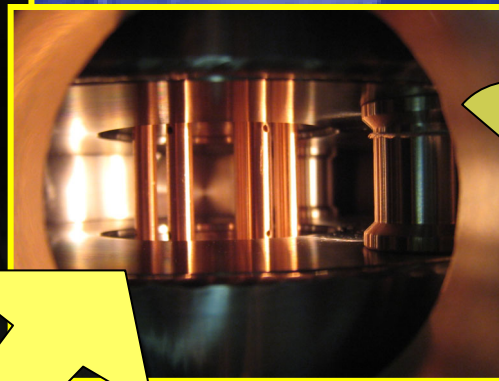
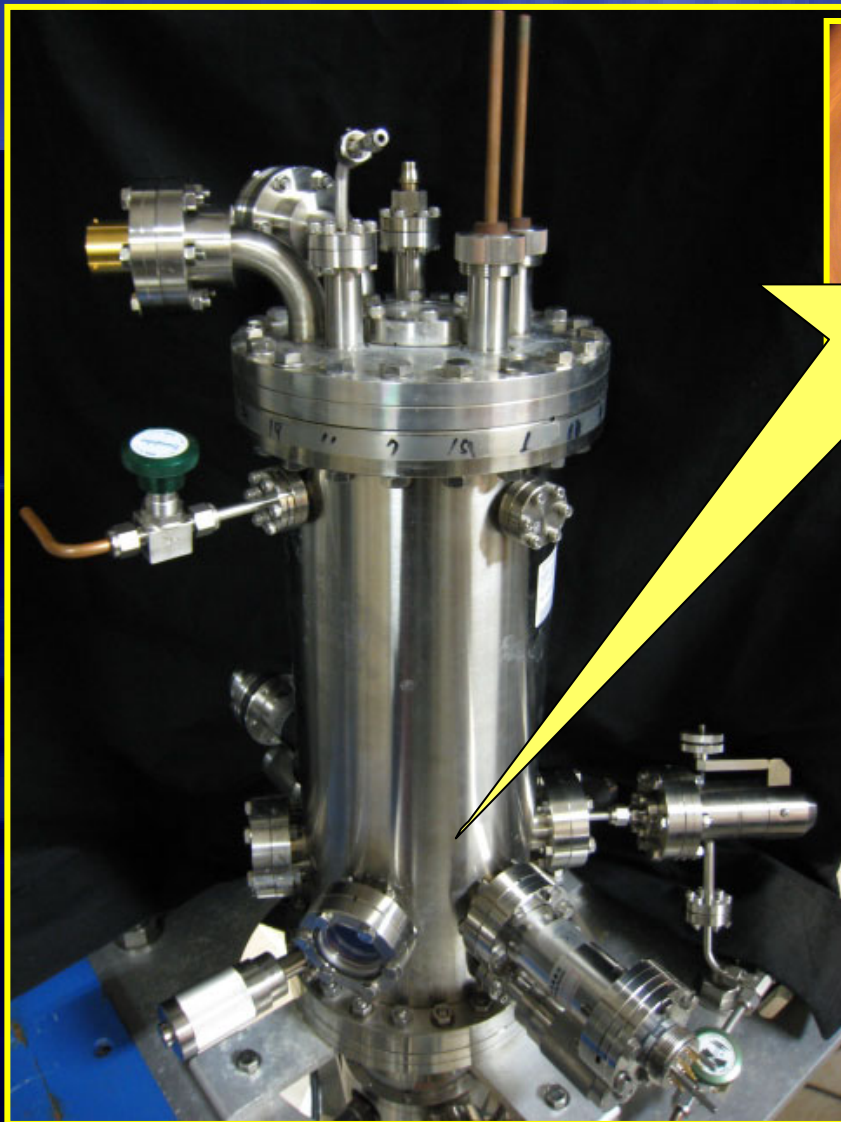
Polarization measurements

- An EBIT is a useful device to study the anisotropy of the radiation because it has a monoenergetic unidirectional electron beam.
- Observations are usually done at 90° with respect to the e-beam.
- From the difference between the experimental intensity ratio and the 4π integrated line intensity ratio, the polarization of the line can be deduced.



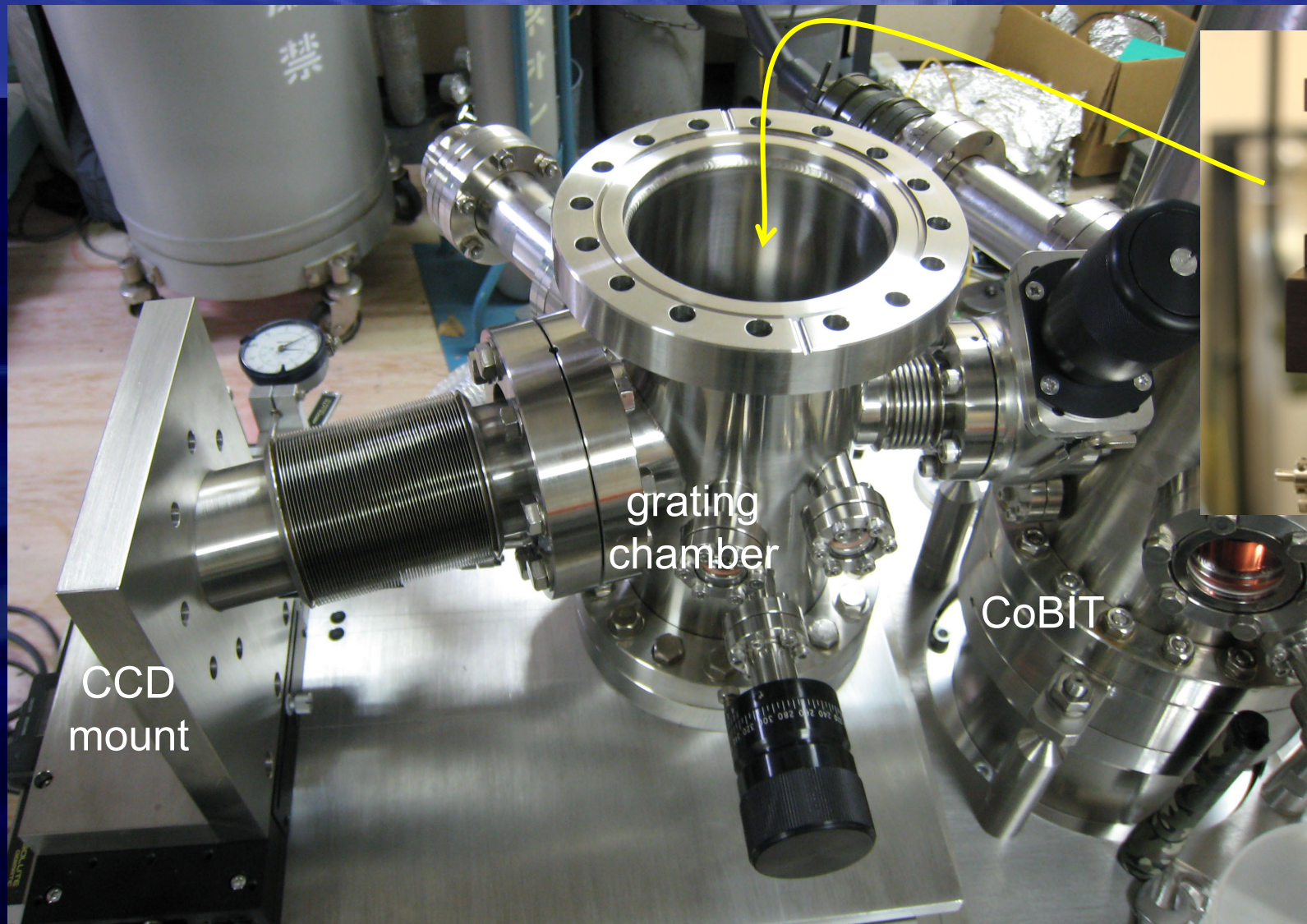
太陽大気を小型実験装置に再現

太陽大気と同じ鉄多価イオン
を実験室で再現して研究！



国立天文台
との共同研究

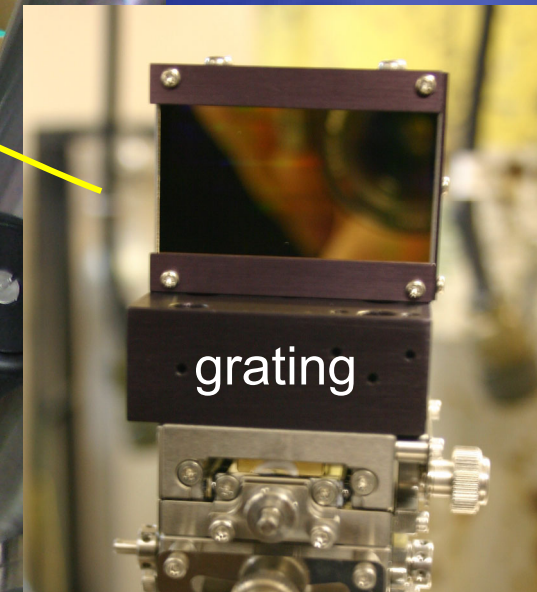
EUV spectrometer for CoBIT



CCD
mount

grating
chamber

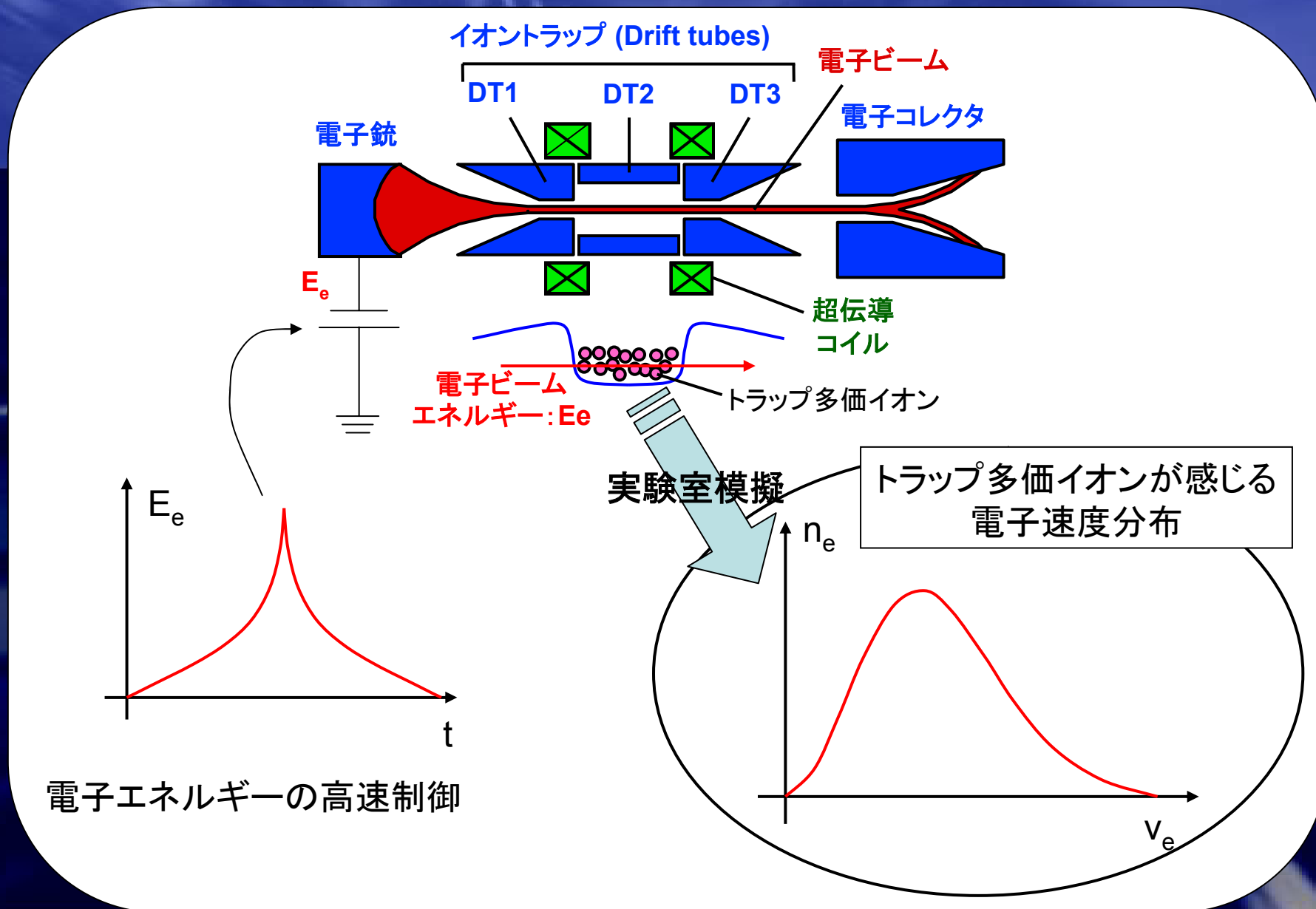
CoBIT



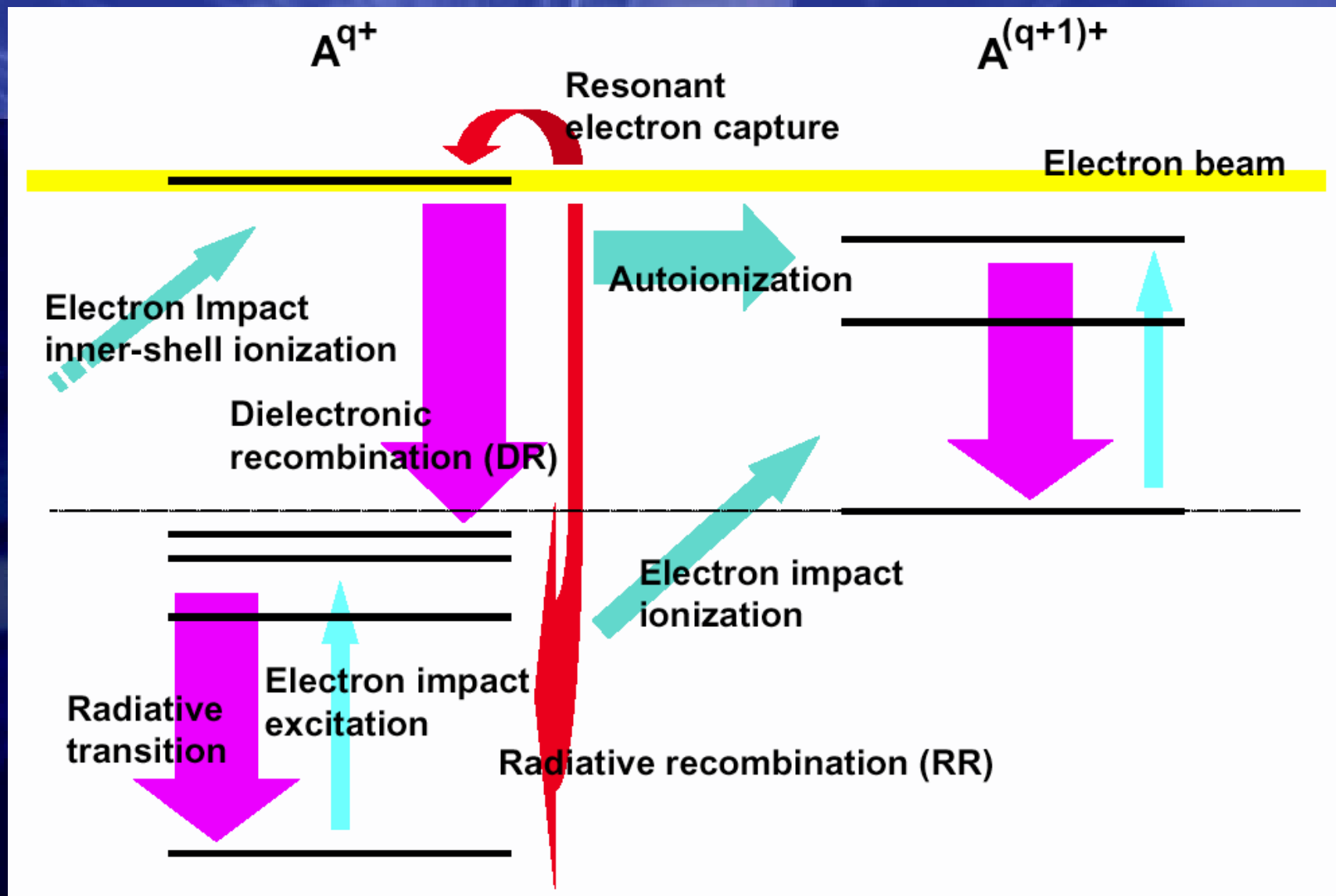
grating

SHIMADZU
(30-002)
Flat-field
1200 g/mm

任意速度分布プラズマの実験的模擬

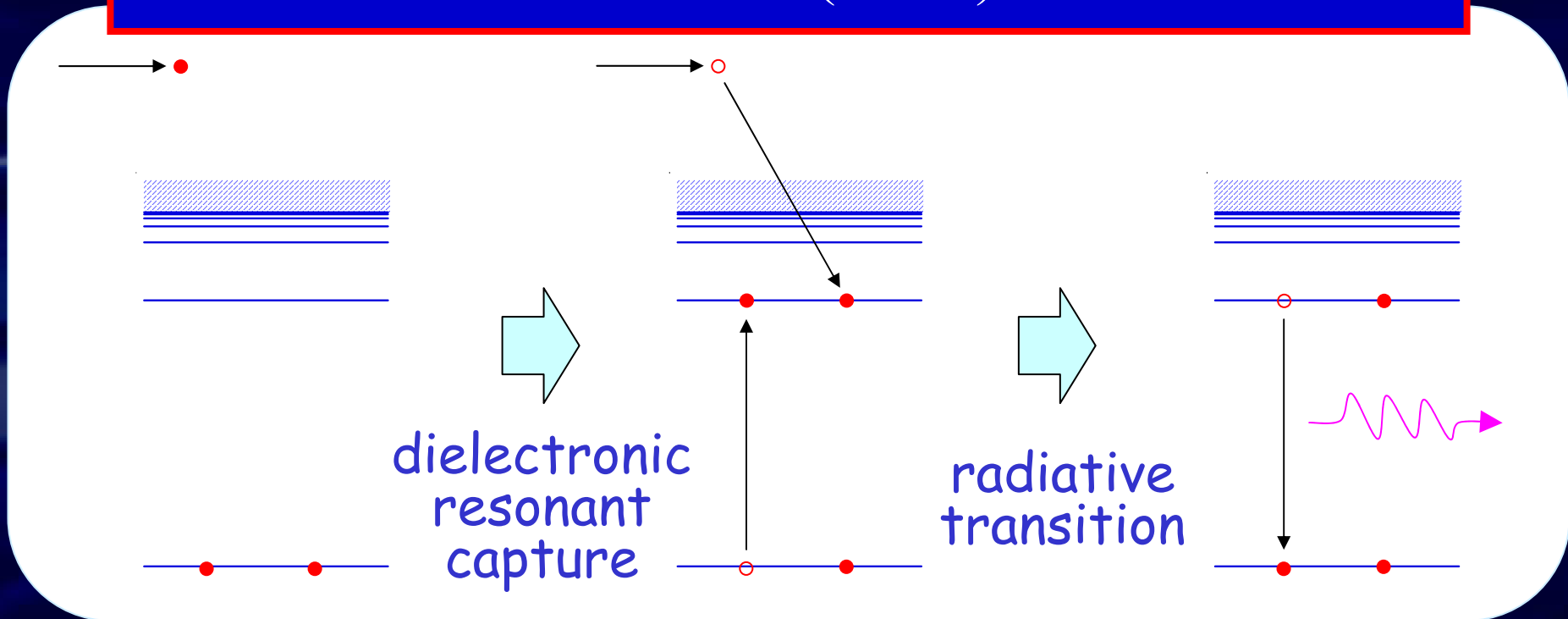


Atomic Processes in an EBIT

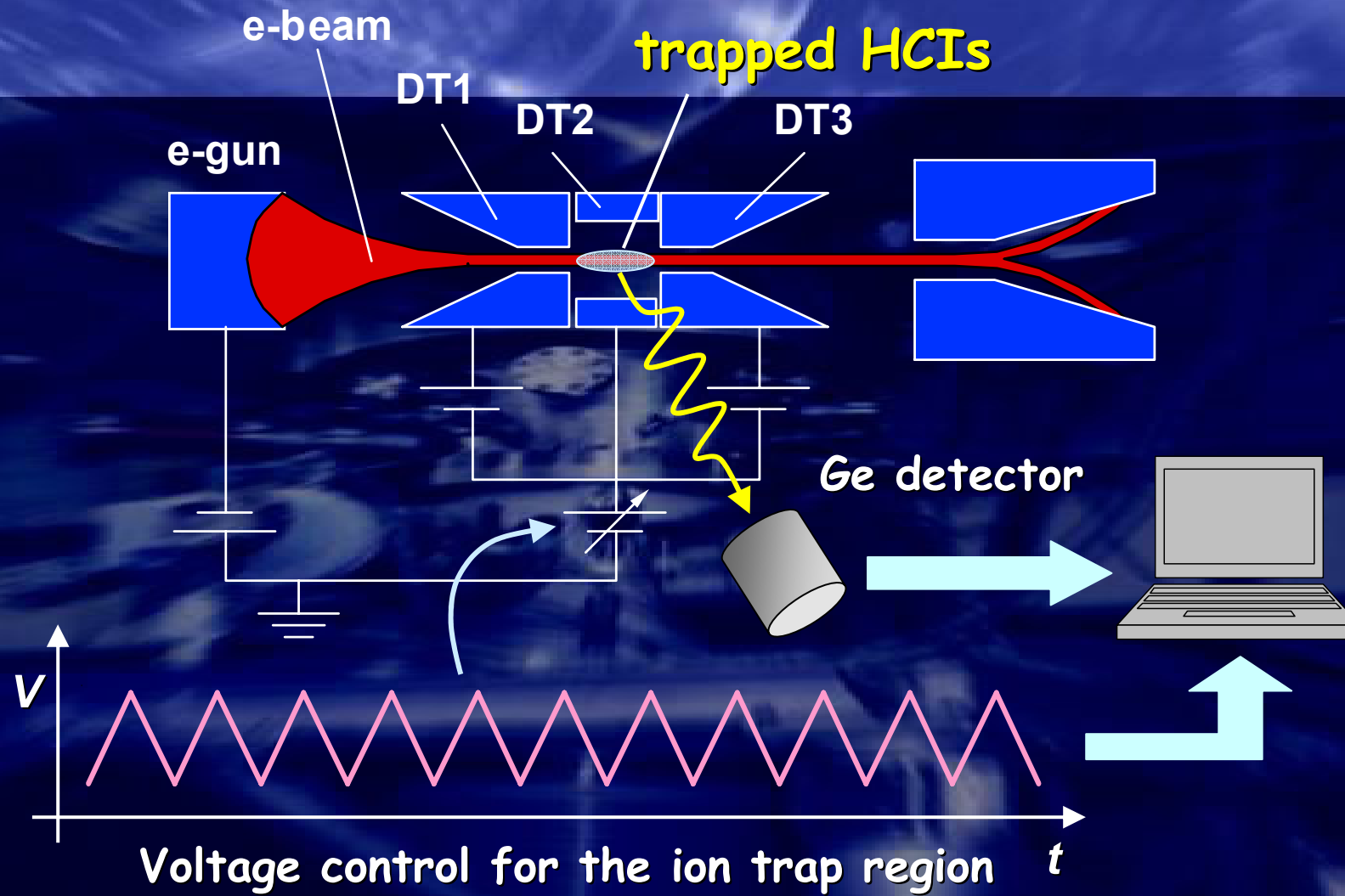


Resonant processes in e-HCl collisions

~ Dielectronic recombination (DR)~

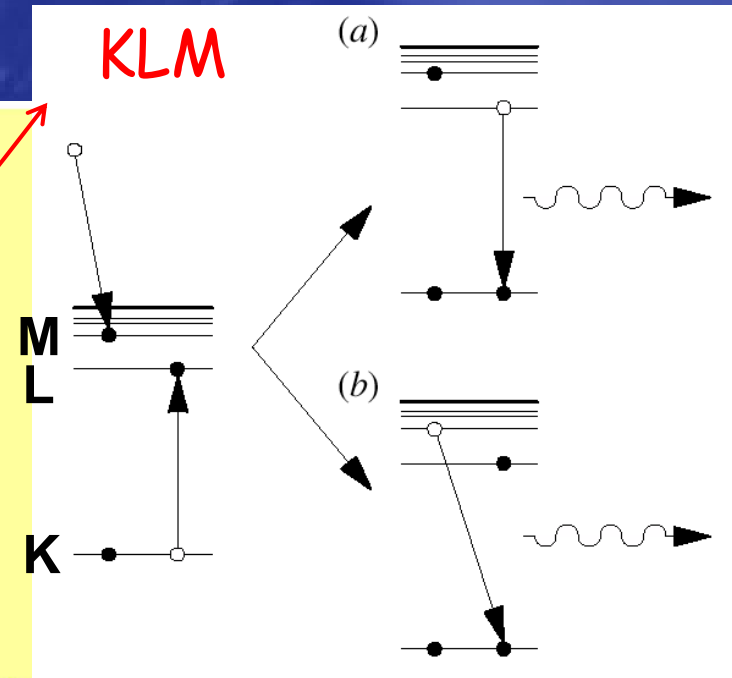
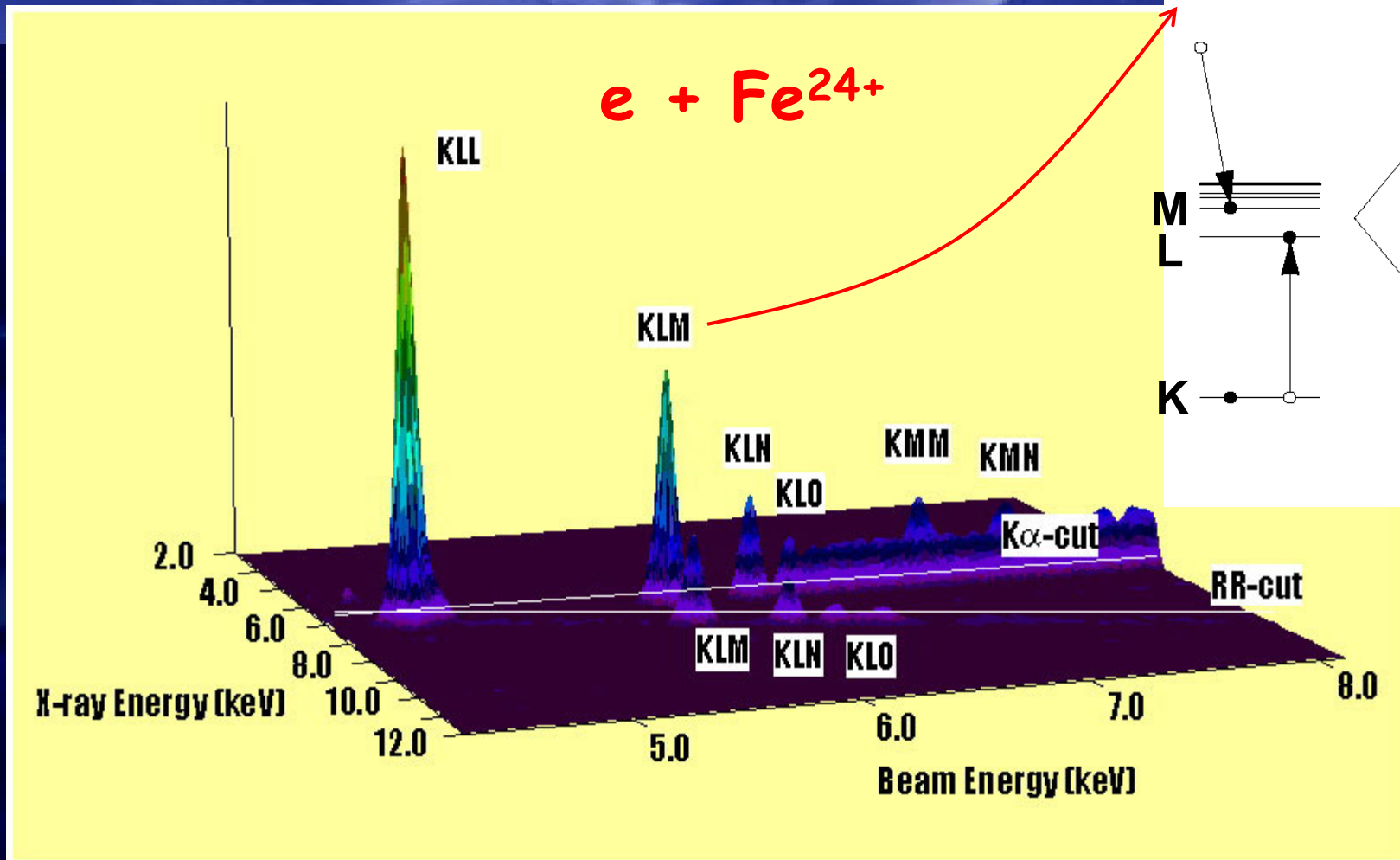


X-ray observation

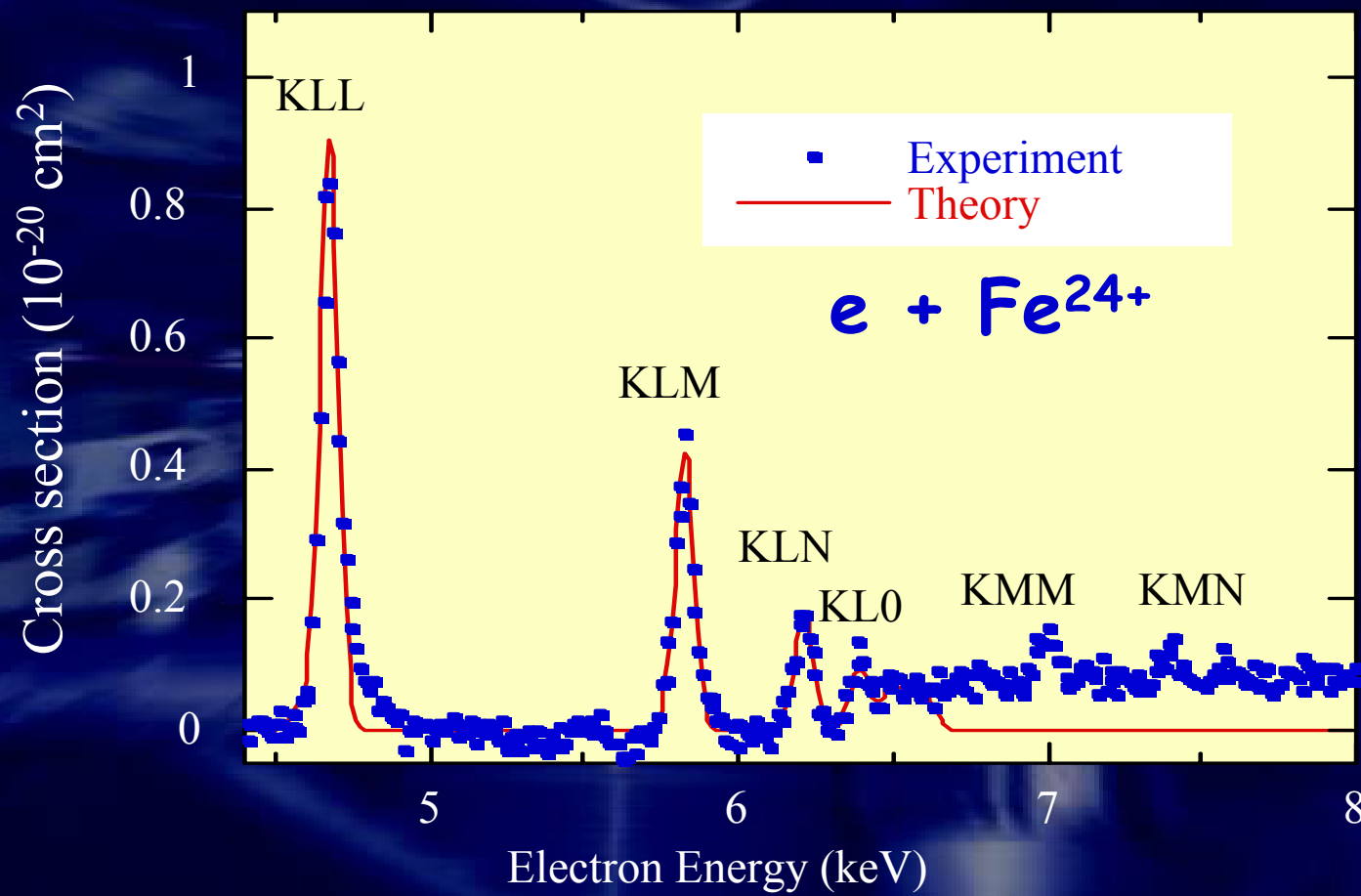


Dielectronic recombination X-ray observation for iron ions

B.O'Rourke et al., NIMB 205 (2003) 378

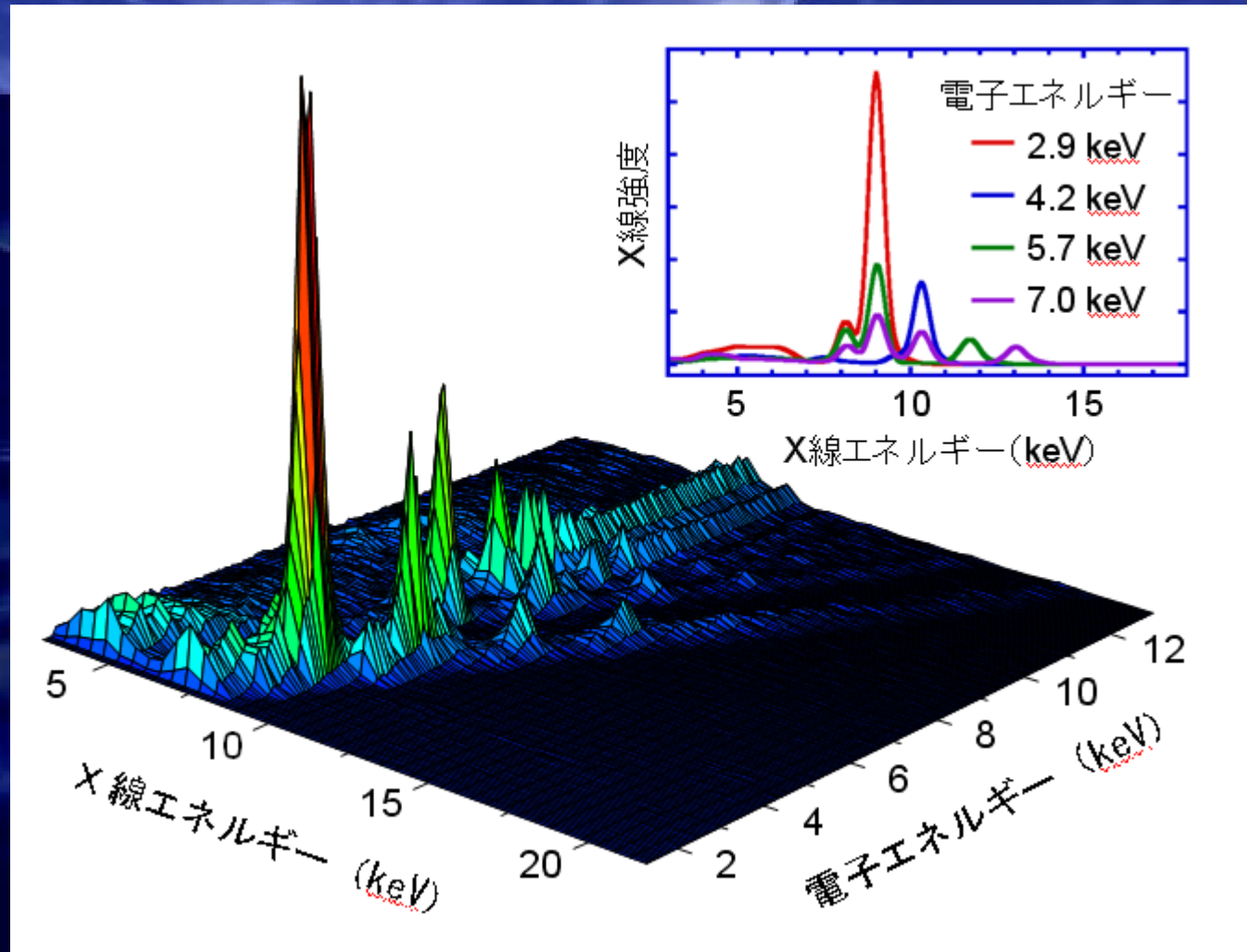


DR Cross Section



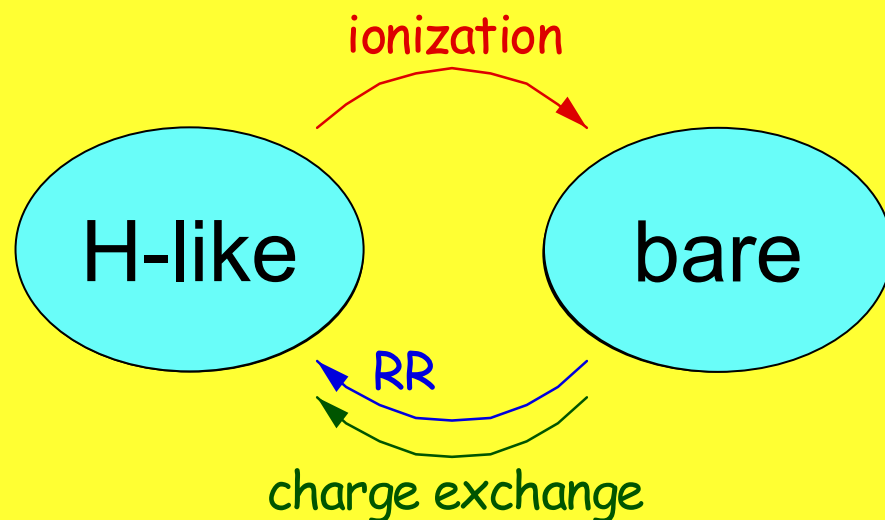
Dielectronic recombination

X-ray observation for tungsten ions



Ionization Cross Section Measurements through RR observation -Principle-

Charge change inside EBIT



Coupling between H-like and bare ions (it is rare that the charge state changes by two at a time)

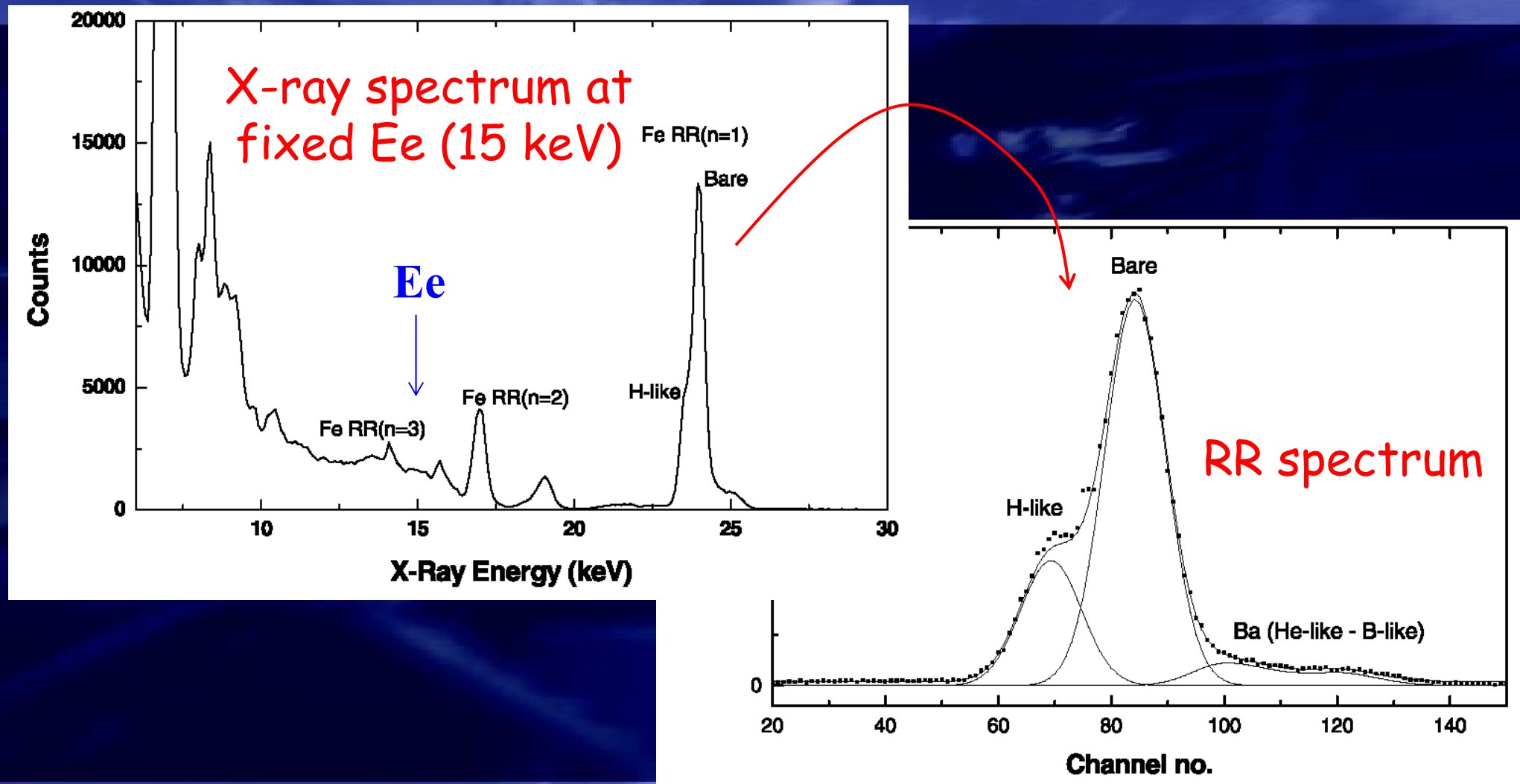
Equation at equilibrium

$$\sigma_{H \rightarrow bare}^{ion} = \frac{N_{bare}}{N_H} \left(\underbrace{\sigma_{bare \rightarrow H}^{RR}}_{theory} + \underbrace{\langle \sigma^{CX} \rangle}_{\rightarrow 0} \right)$$

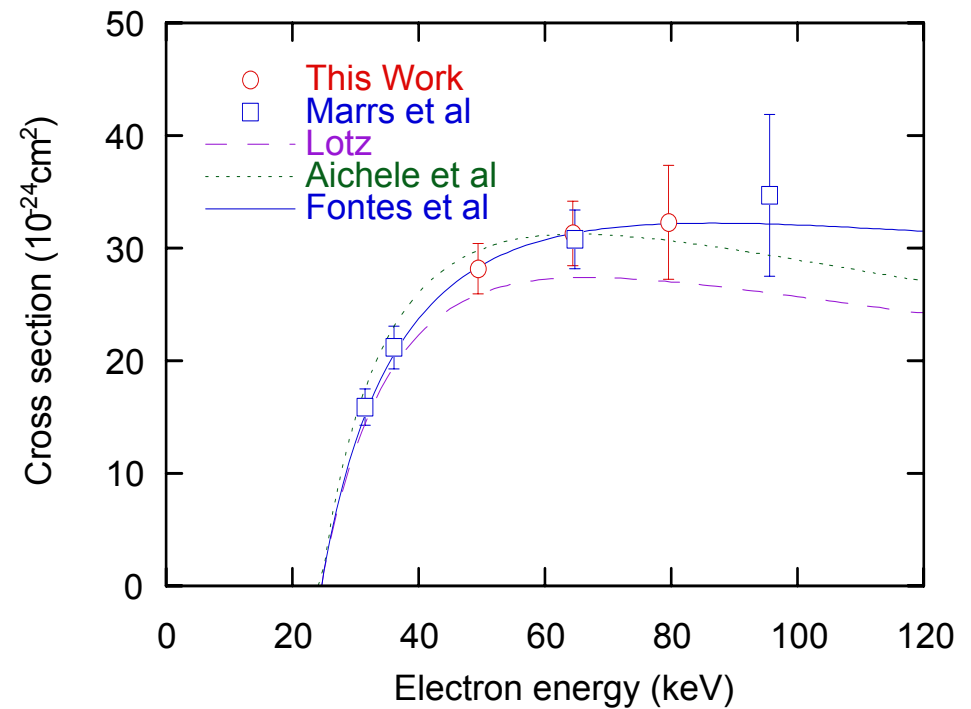
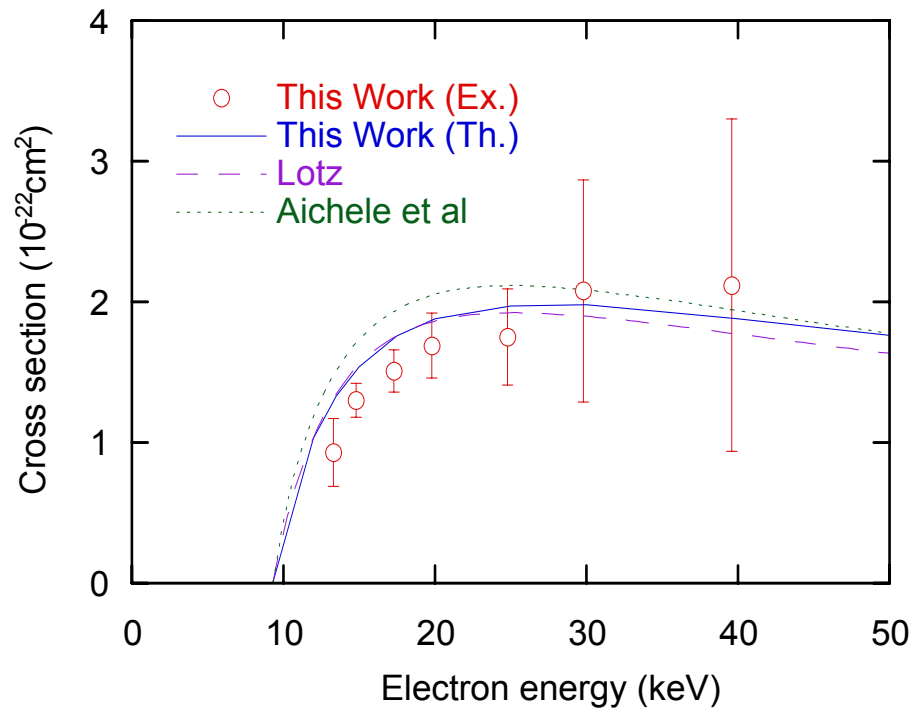
$$\frac{N_{bare}}{N_H} = \frac{\sigma_{H \rightarrow bare}^{RR}}{\sigma_{bare \rightarrow H}^{RR}} \cdot \frac{I_{bare}^{RR}}{I_H^{RR}}$$

theory
measure

Ionization Cross Section Measurements through RR observation -RR spectrum-



Ionization Cross Section Measurements through RR observation -Results-



共同研究者＋お世話になっている方々

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