

**Studies in atomic and molecular physics  
making use of the timing characteristics of  
synchrotron radiation**

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KEK-PF

gas phase  
atom, molecule

A +

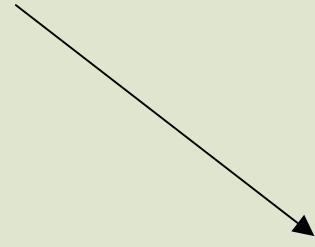
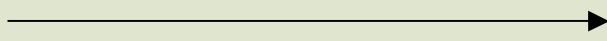
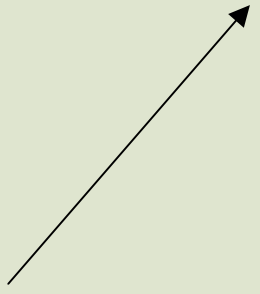
photon

resonant state  
or  
intermediate state

A\* (+ electron)  
(+photon)  
(ion)

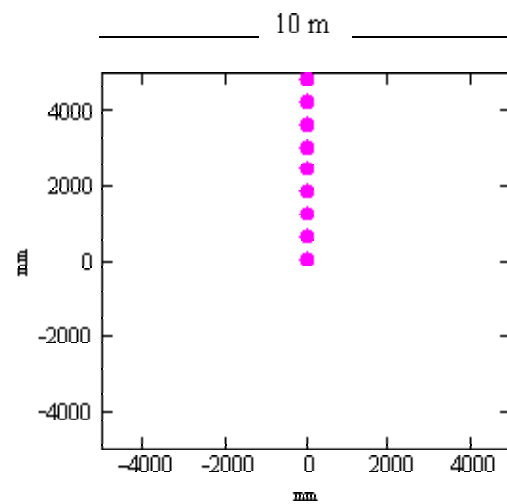
0-100eV

Time-resolved  
detection using  
MCP, channeltron,  
ETP etc.



## At the TARGET

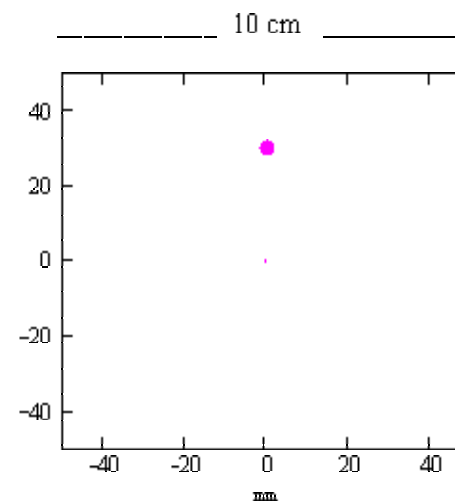
time = -0.10 ns



**Light**

$$v_L = 3.0 \times 10^8 \text{ m s}^{-1}$$

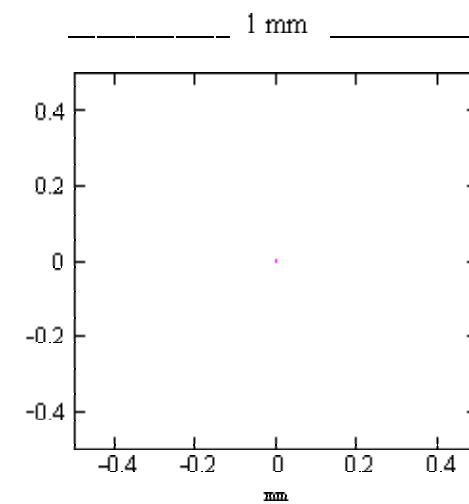
**i.e. 300 m us<sup>-1</sup>**



**Electrons  
40 eV**

$$v_e = 3.8 \times 10^6 \text{ m s}^{-1}$$

**i.e. 3.8 m us<sup>-1</sup>**

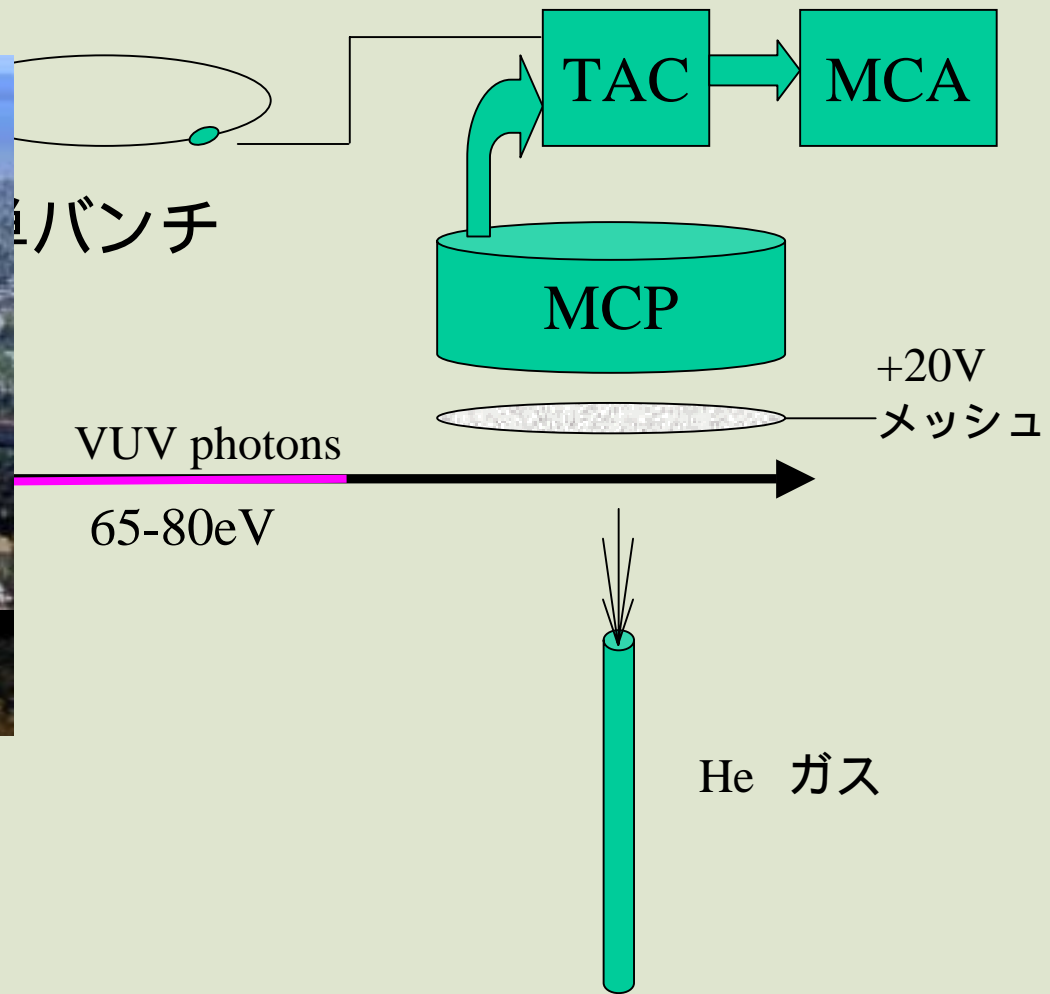


**Atoms  
He 40 meV**

$$v_a = 1.4 \times 10^3 \text{ m s}^{-1}$$

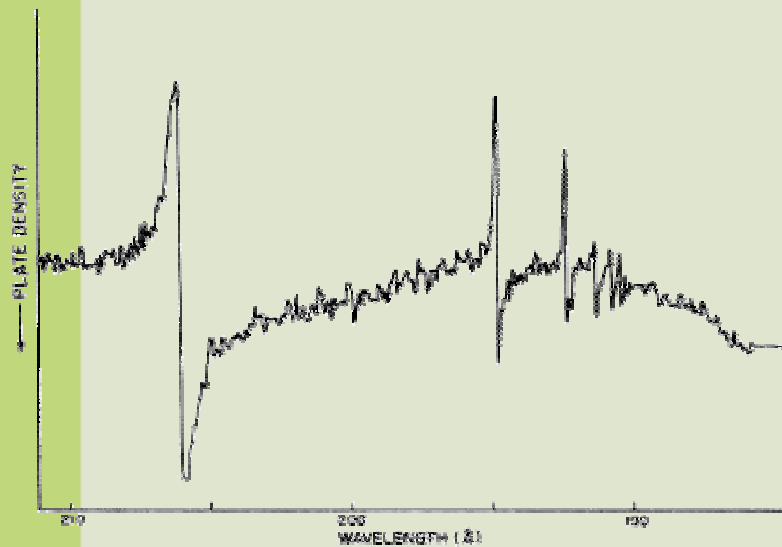
**i.e. 1.4 mm us<sup>-1</sup>**

# 実験装置

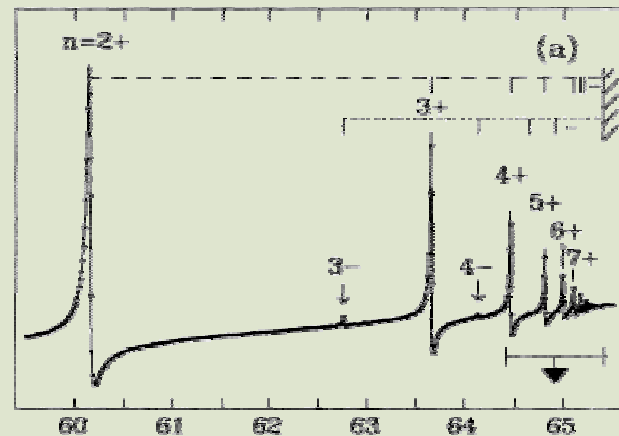


# This is Helium....

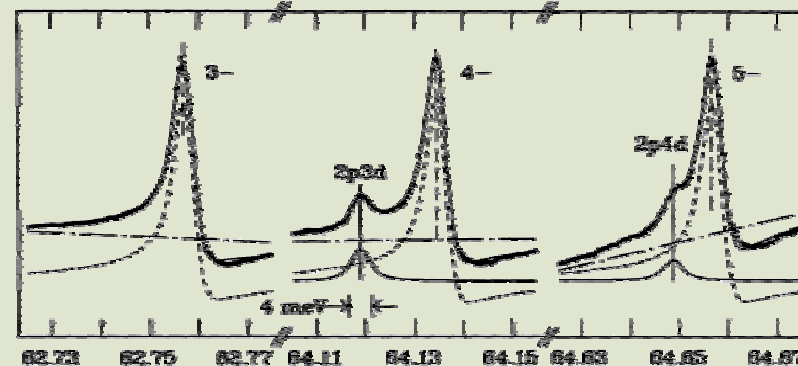
- Strongly LS coupled
  - No forbidden transitions (only  $^1P$  excitations)
  - Doubly excited states autoionise



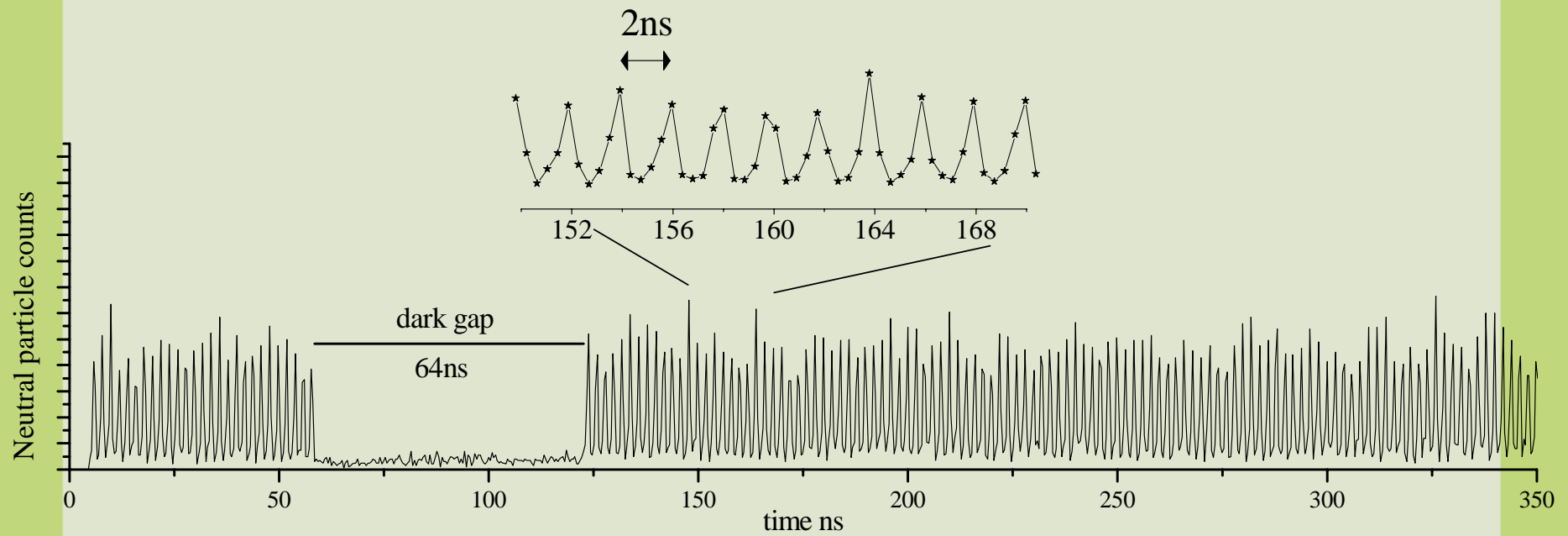
Madden and Codling (1963)



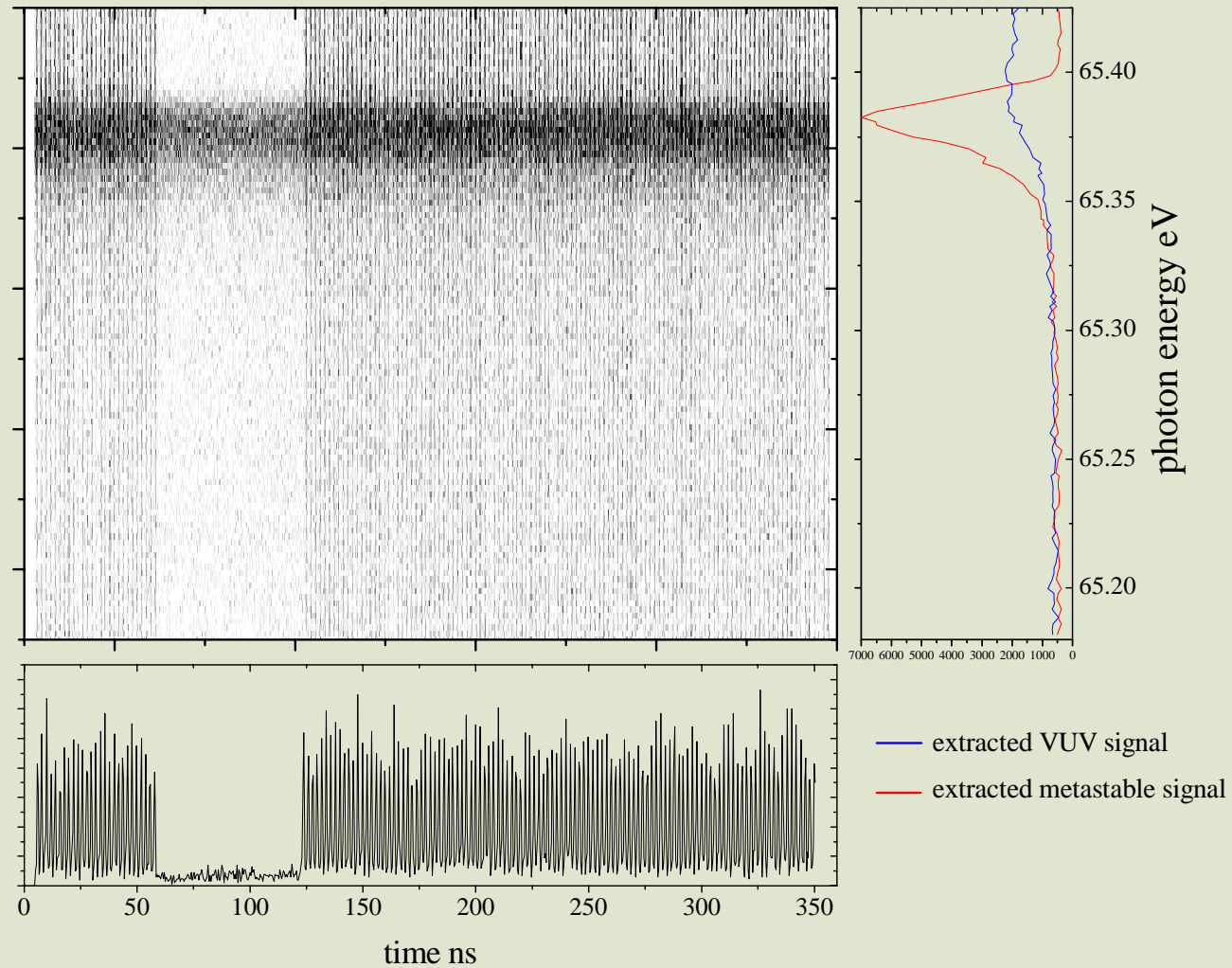
Domke et al. (1992)



# Multi-bunch: separation of “slow” and “fast” processes

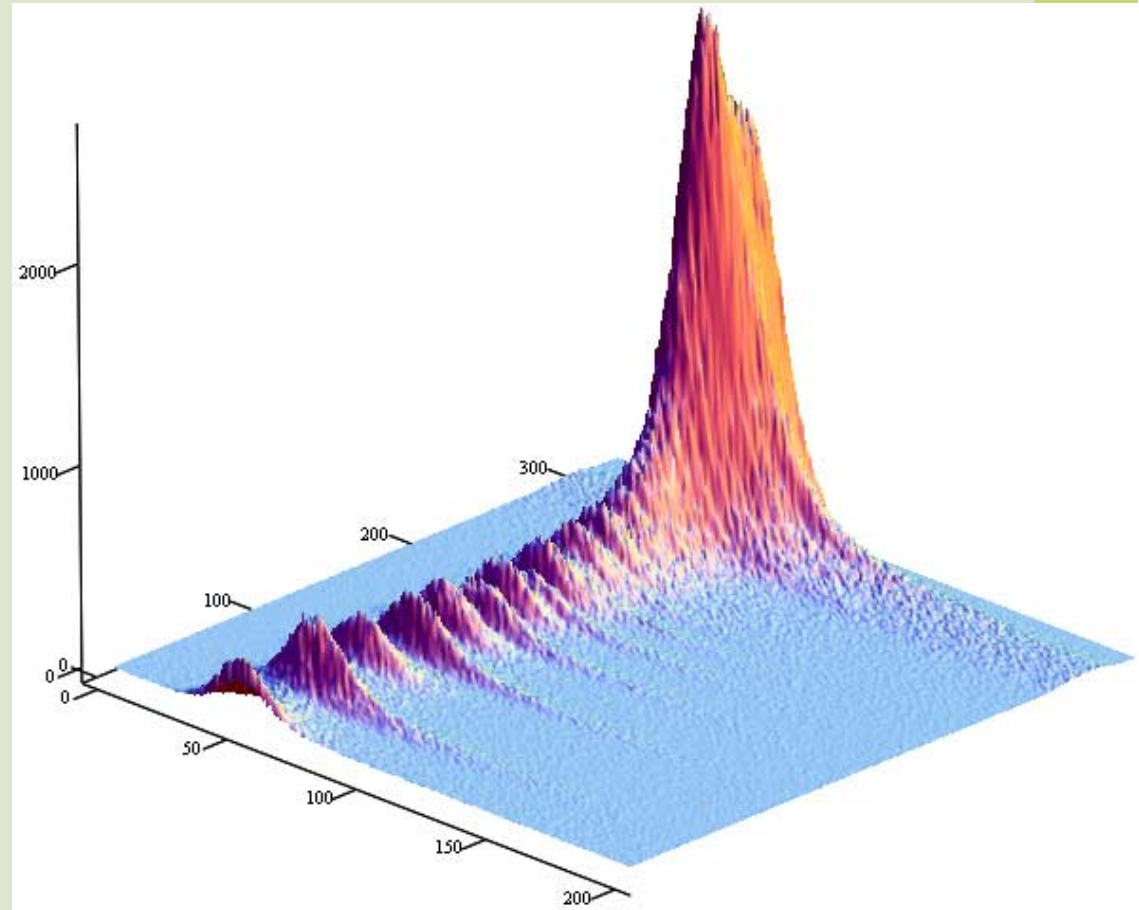


# Separation of VUV and metastables from He\*\*



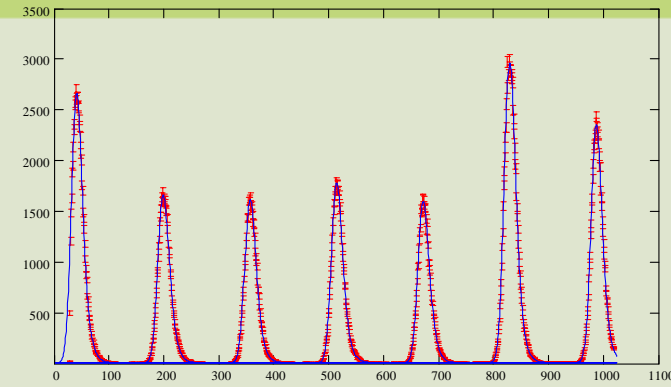
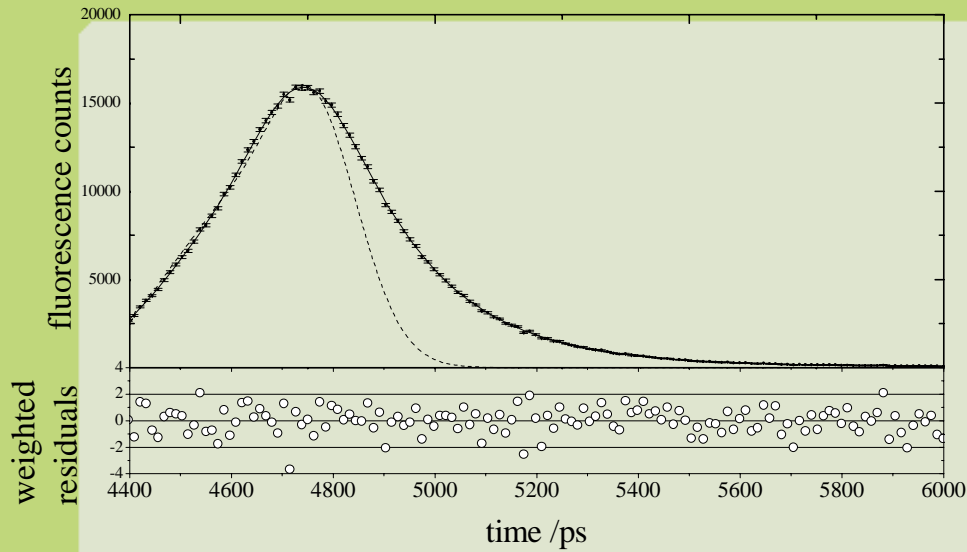
# Lifetime measurements

- Different states have different lifetimes
- 2pnd series  $> 300$  ps
- Close to [sp,2n-] series (at least for high n)
- Lifetimes up to 60 ps



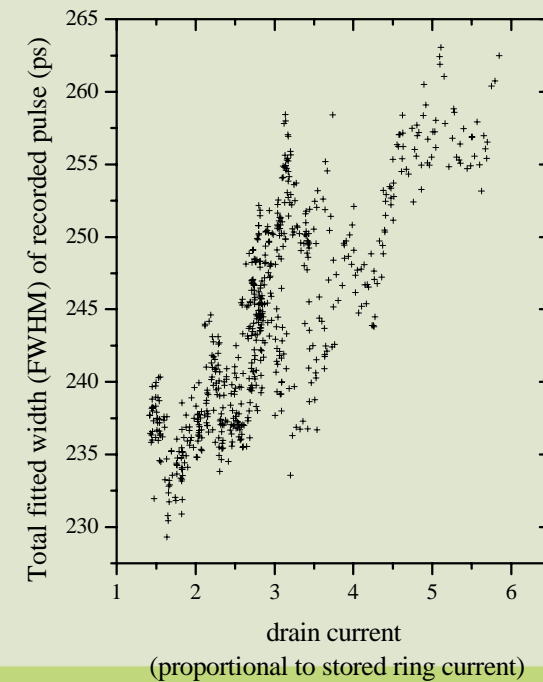


# Lifetime fitting data

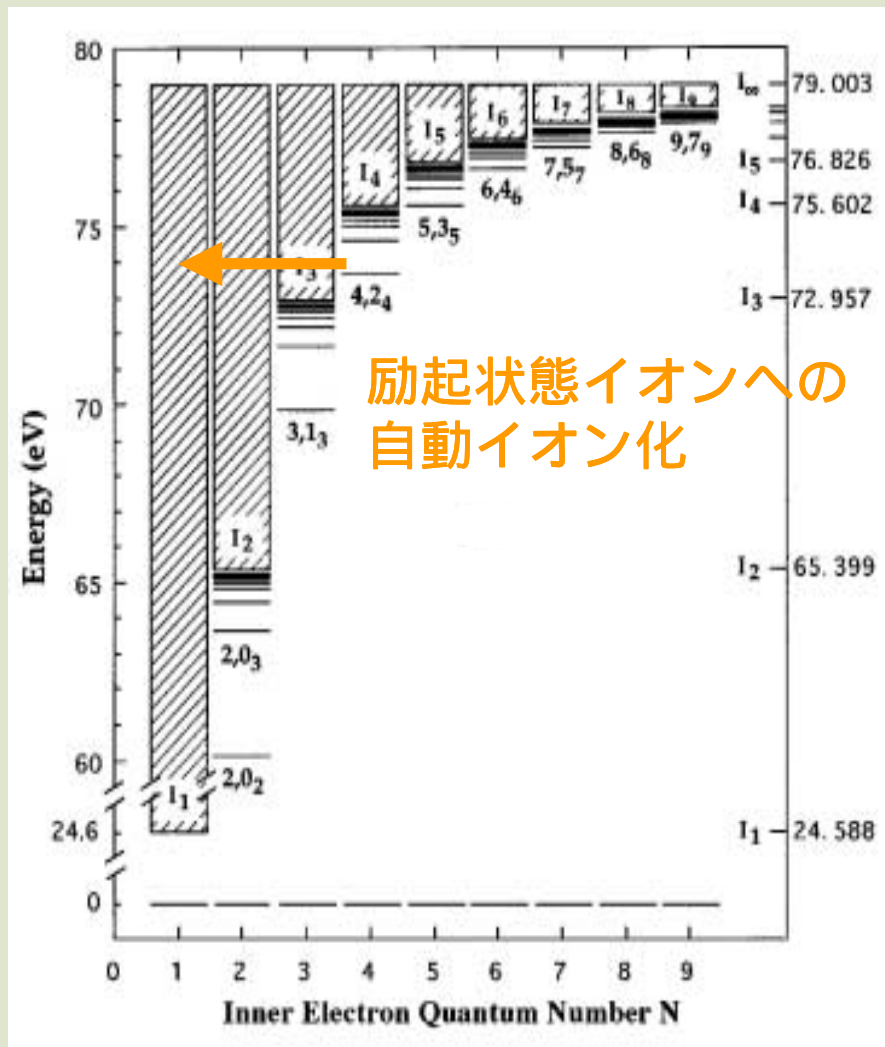


Timescale calibration by fitting Gale's functions.

- Data recorded at Photon Factory
  - Very stable operation



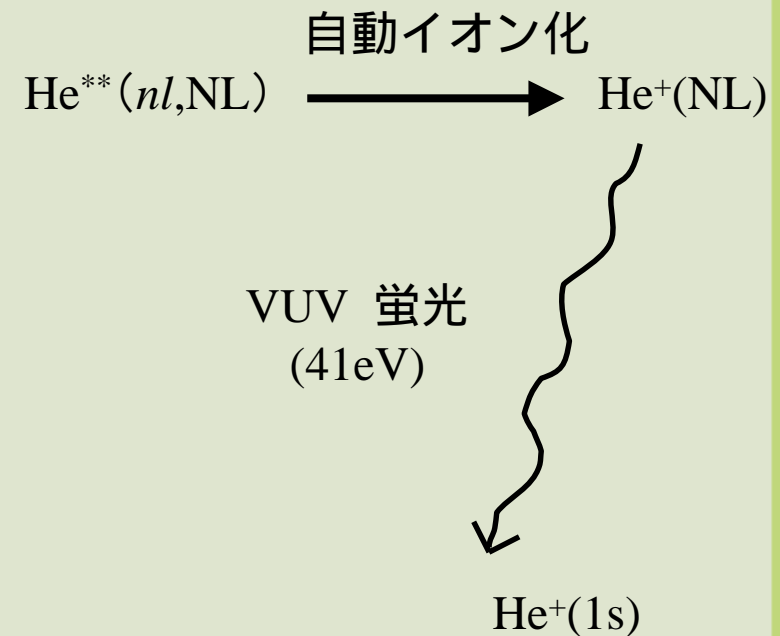
# 実験の概念



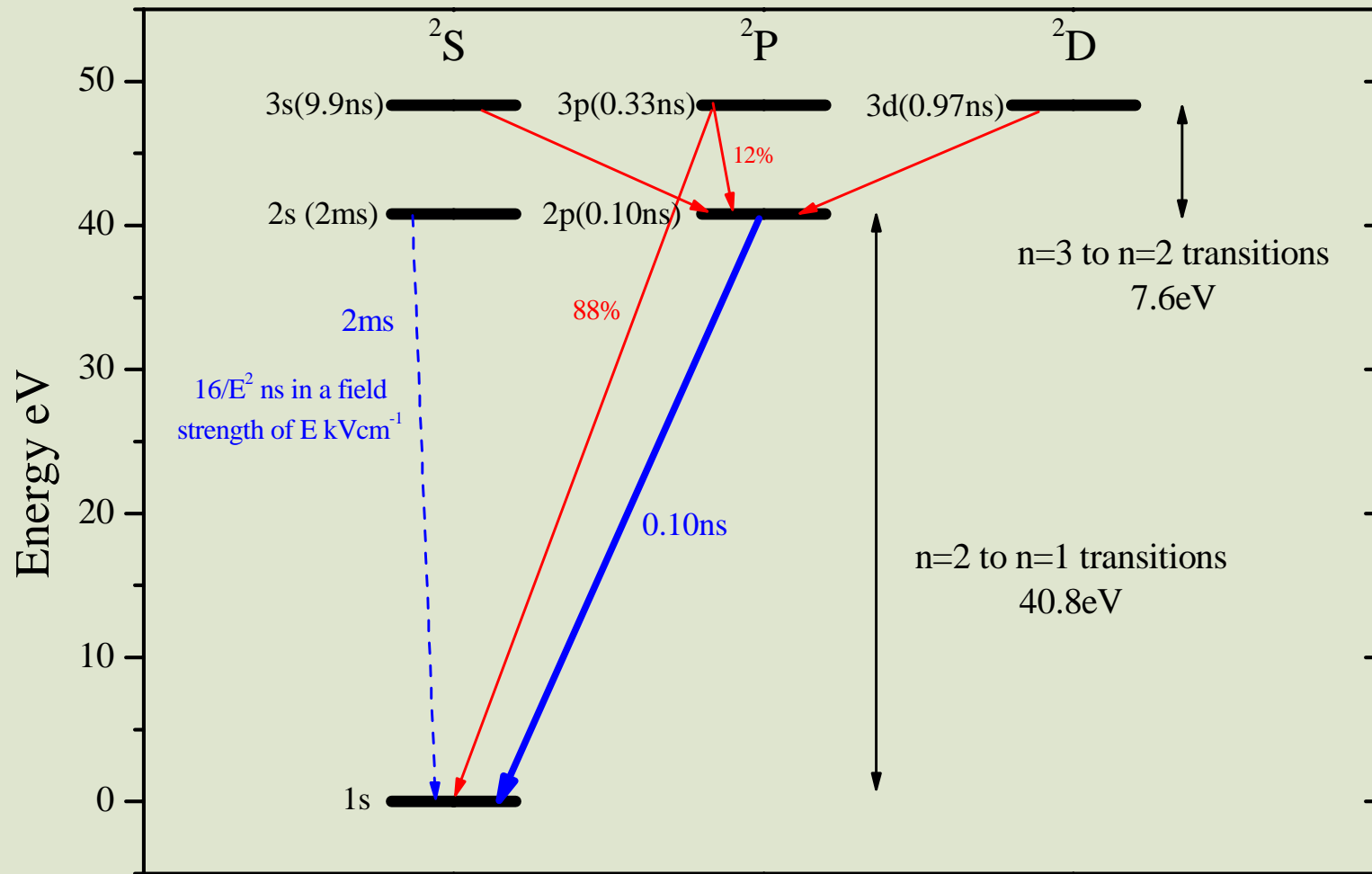
Domke *et al.* Phys.Rev.A 53(3)1424(1996)

ヘリウムの2電子励起状態の崩壊ルート:

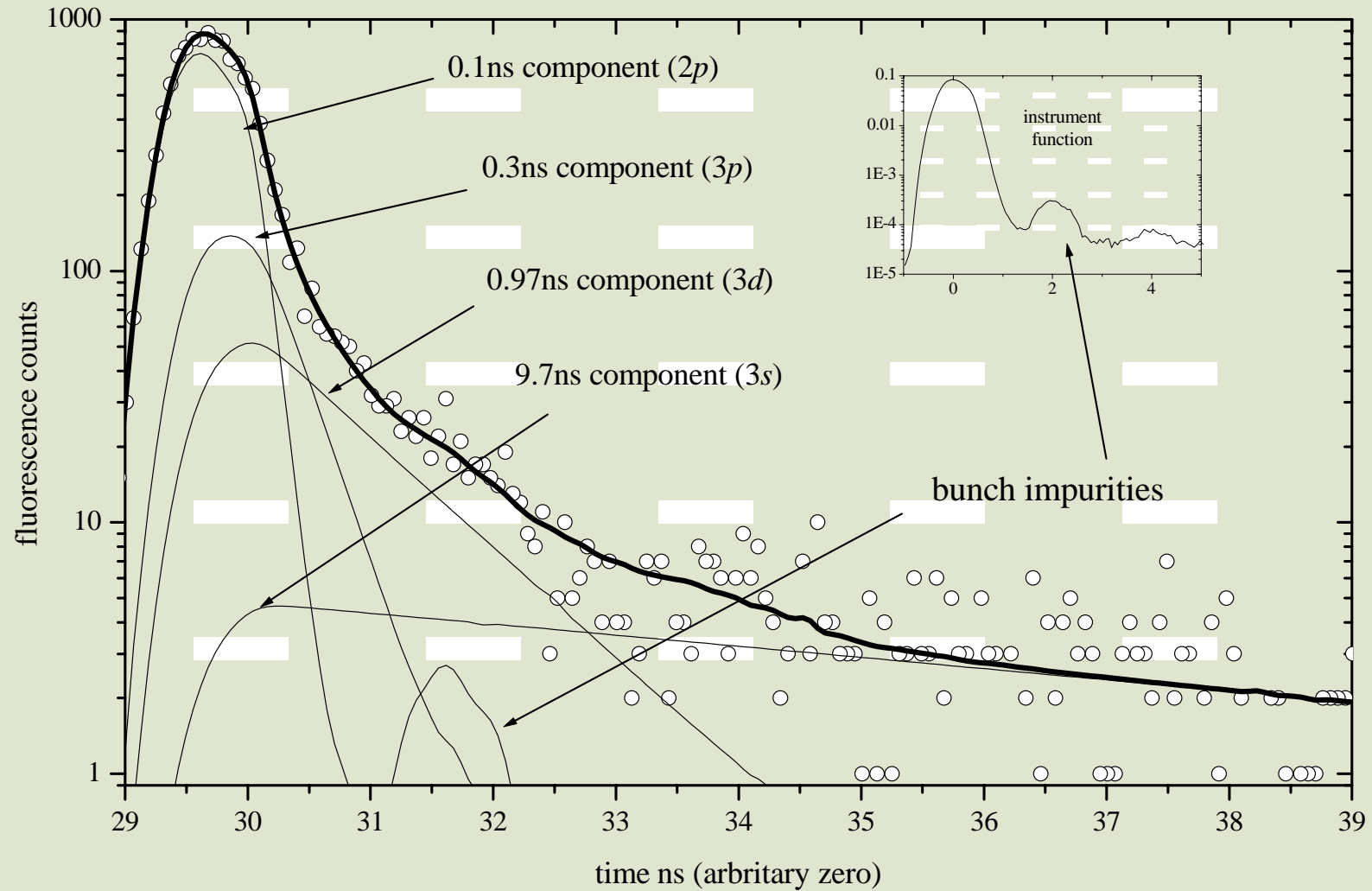
- 自動イオン化 vs. 蛍光
- 基底状態へvs. 励起状態へ

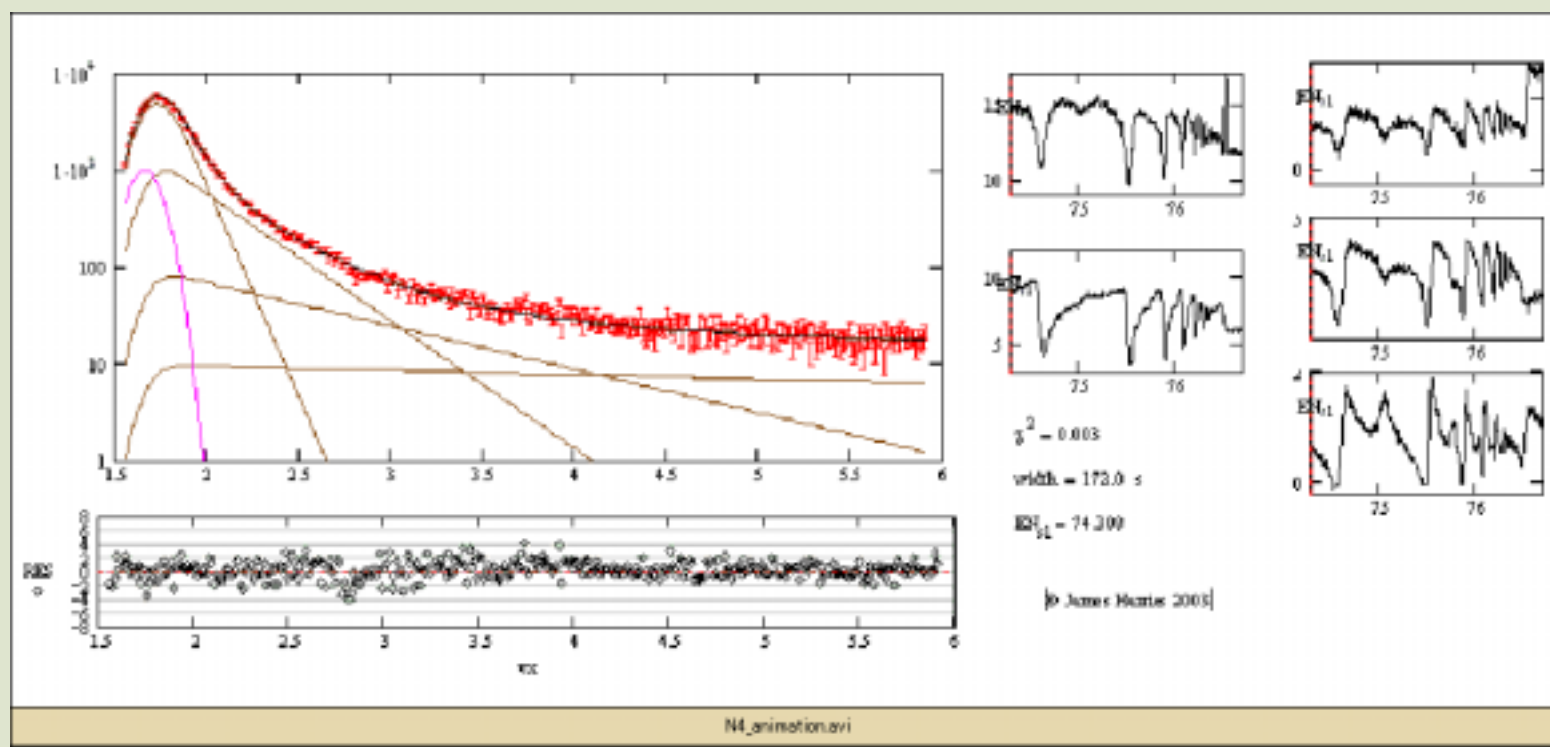


# ヘリウムイオン (N=2,3) 蛍光寿命

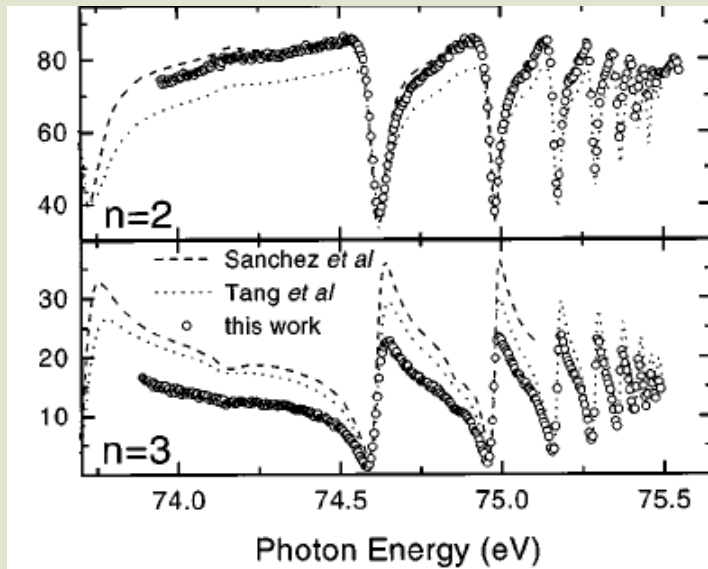


# 蛍光データ

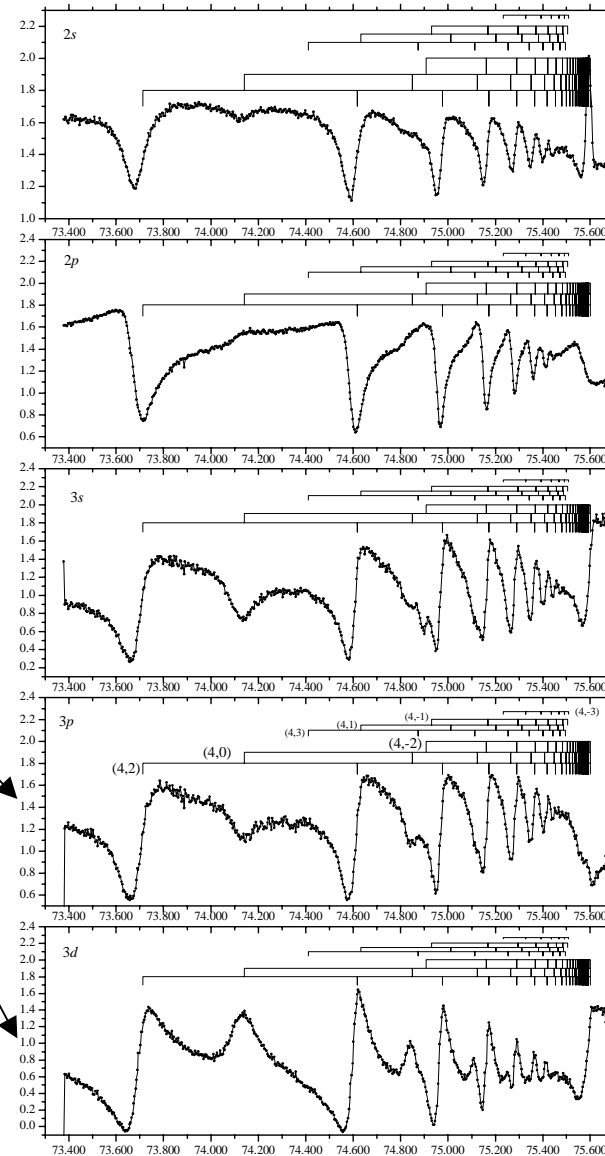




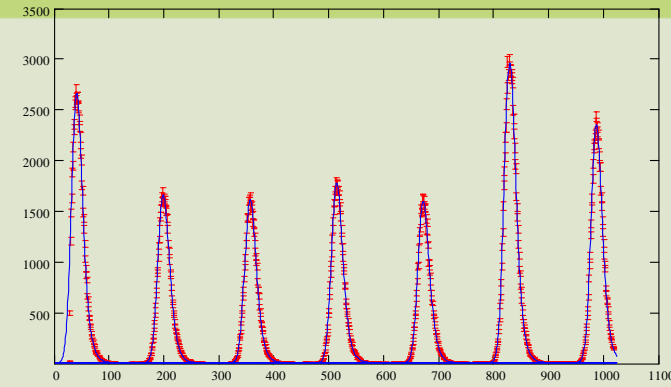
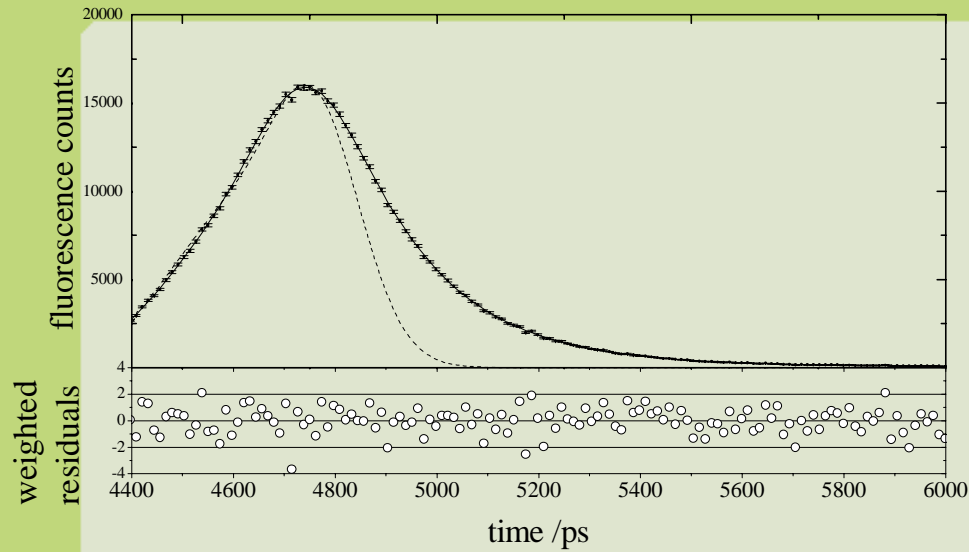
# 従来の実験法 (電子エネルギー分光)



新しい“寿命別分光”  
実験法

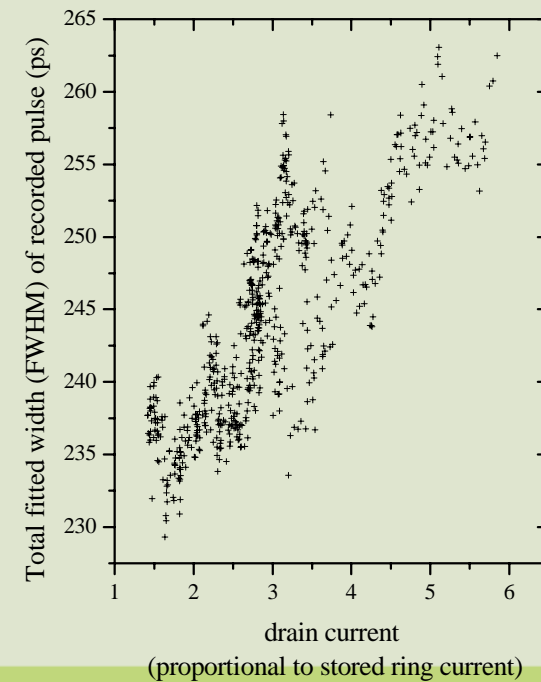


# Lifetime fitting data

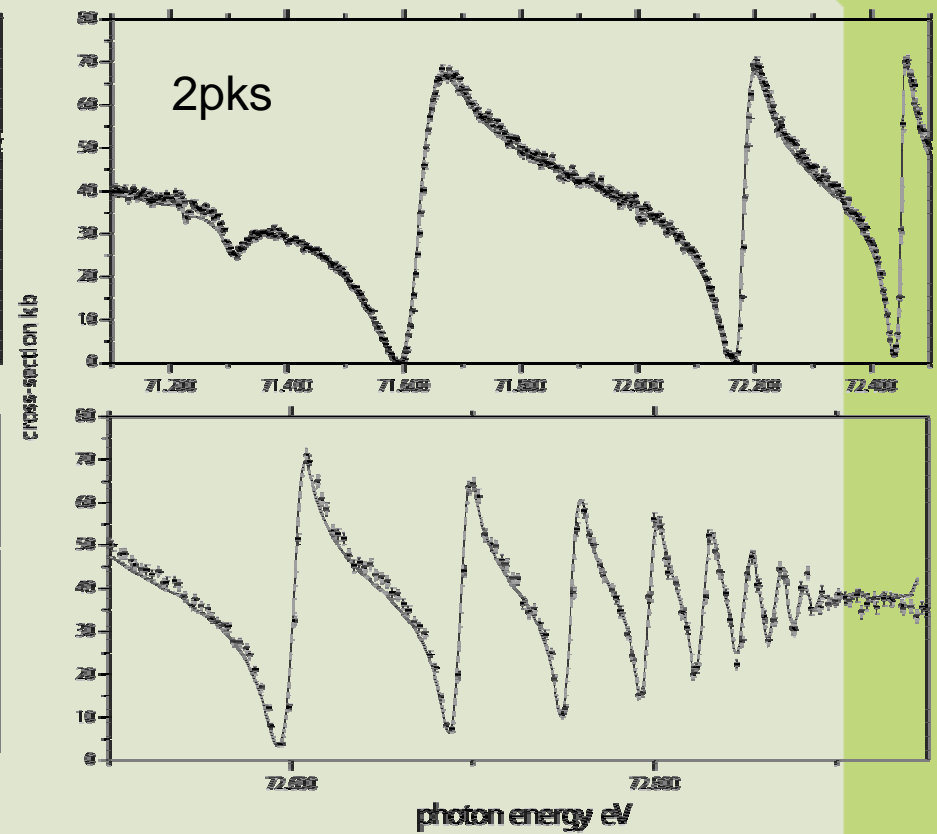
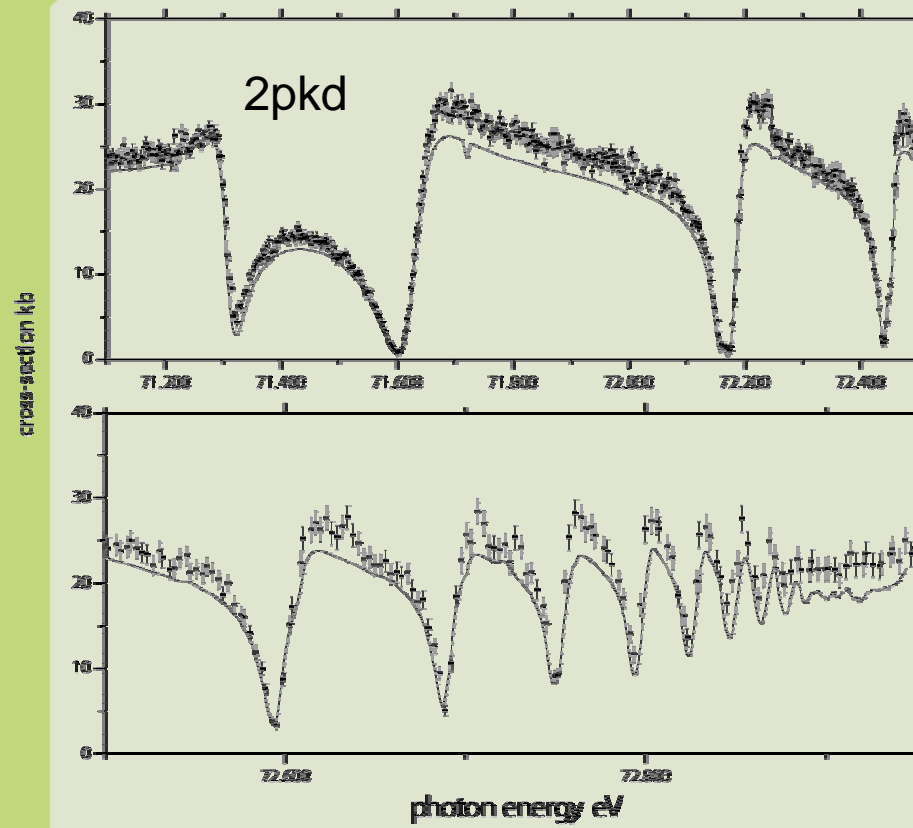


Timescale calibration by fitting Gale's functions.

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  - Very stable operation



# Ion alignment





# Lifetime fitting results

- Two lifetime components
  - Measurable ( $>50$  ps)  $2n$ - lifetime only at high  $n$  - maybe

