

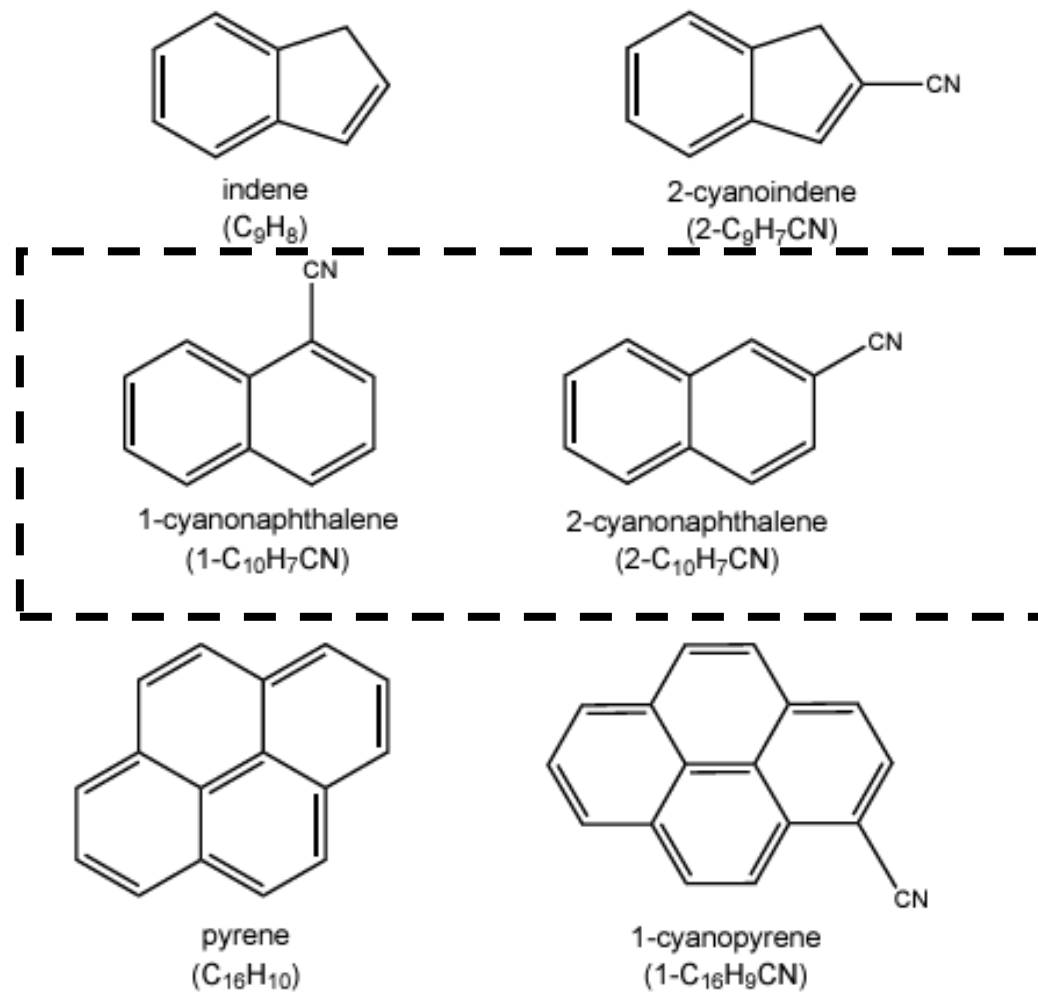
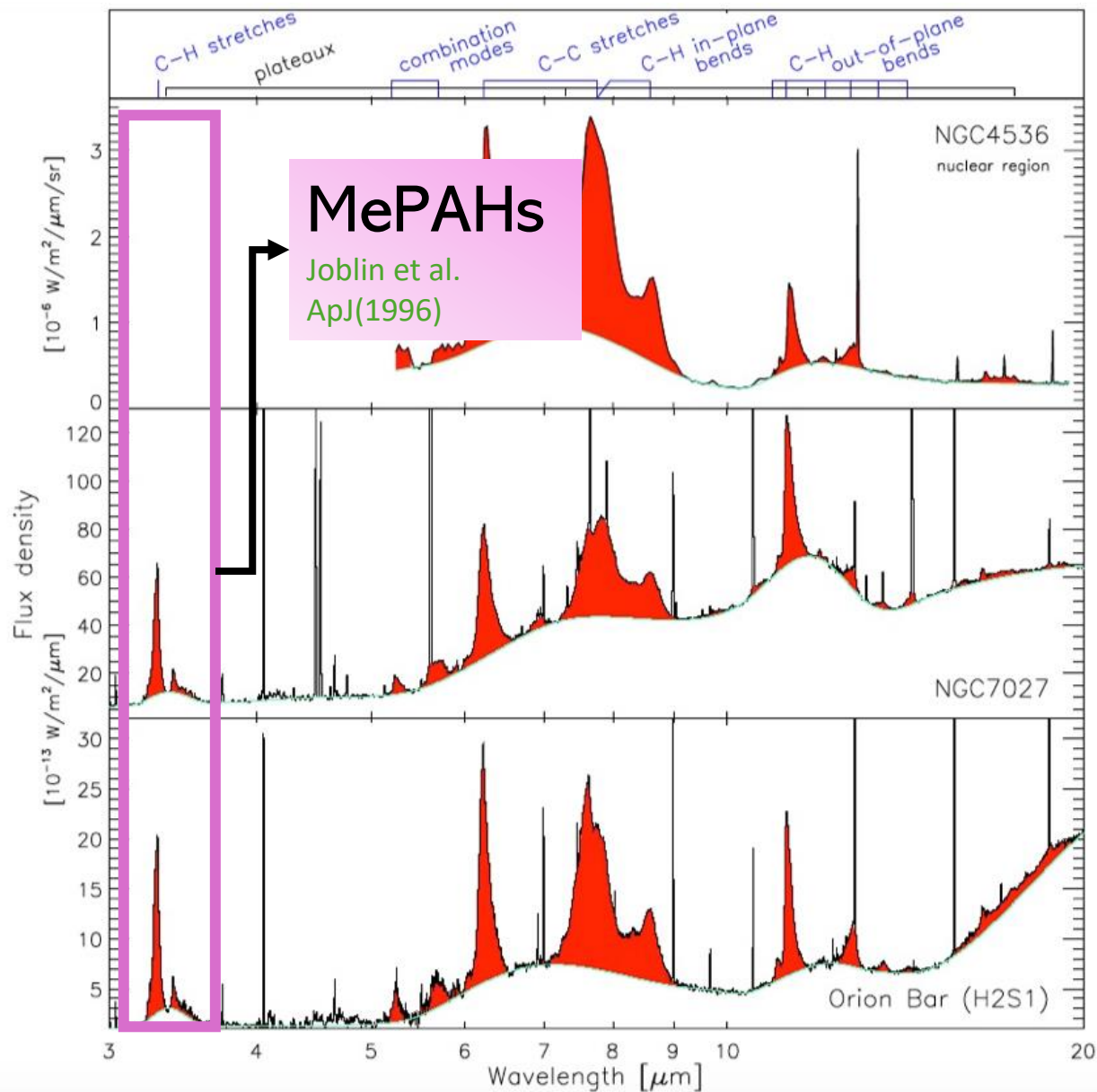
# Investigating the photophysics and isomerization of $C_{11}H_9^+$

ANA I. LOZANO  
(IRAP, Toulouse)  
30/10/2024



pcmi2024  
Bordeaux

# INTERSTELLAR PAHs

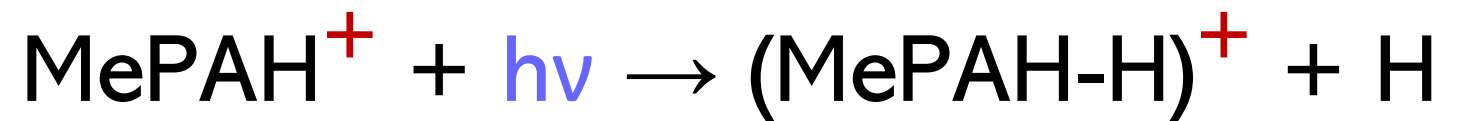
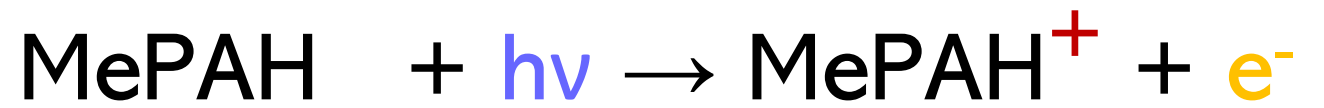
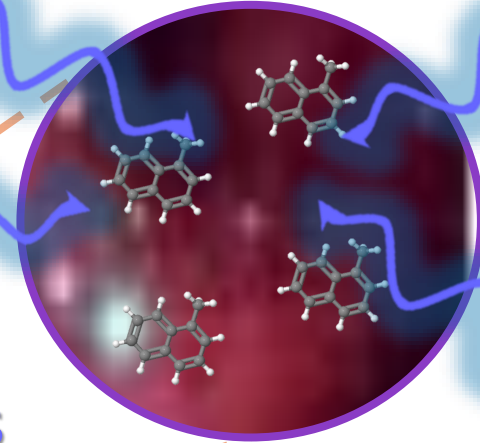


## PHOTODISSOCIATION REGIONS



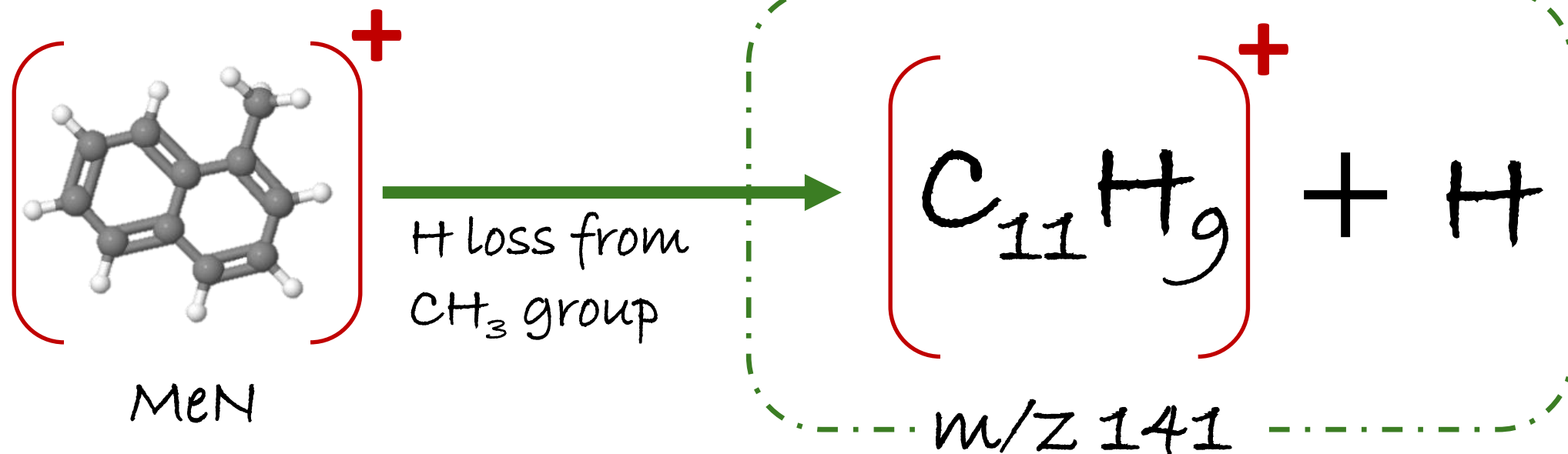
© NASA, ESA, CSA, PDRs4All ERS

UV PHOTONS



Marciniak et al. A&A(2021)

(METHYLNAPHTHALENE-H)



- How fast does  $\text{C}_{11}\text{H}_9^+$  relax?
- Which are the long-lived isomers?

- How fast does  $C_{11}H_9^+$  relax?

Mini-Ring (Lyon)

- Which are the long-lived isomers?

PIRENEA (Toulouse)



time

- How fast does  $C_{11}H_9^+$  relax?

Mini-Ring (Lyon)

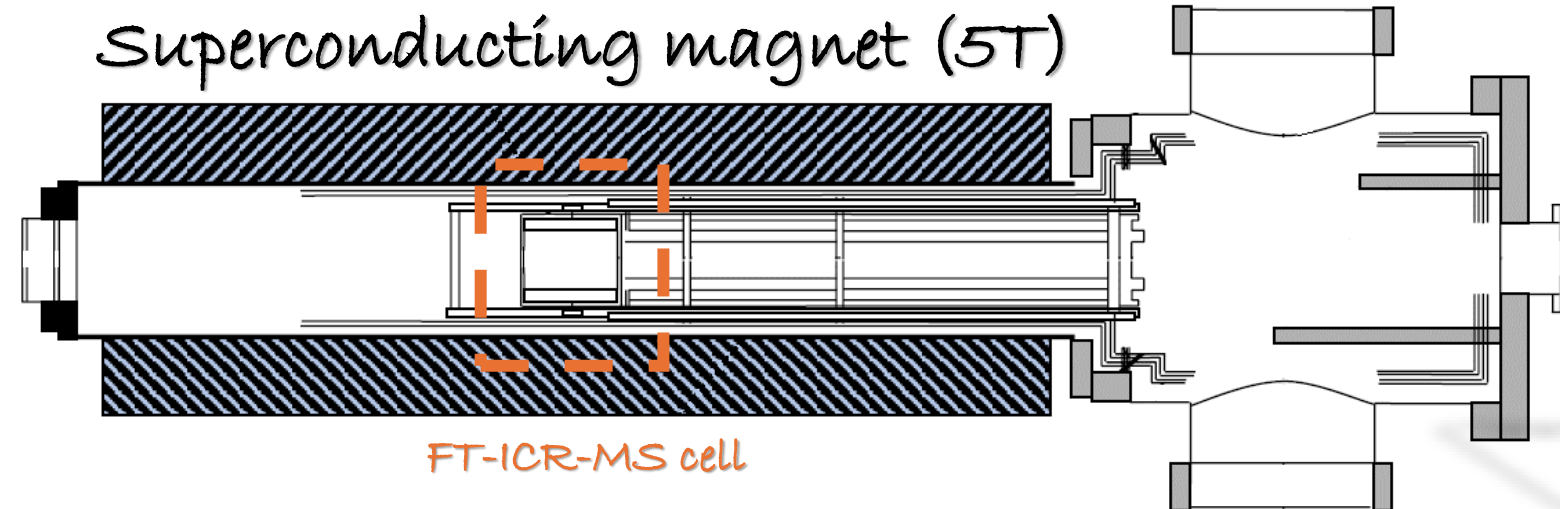
- Which are the long-lived isomers?

PIRENEA (Toulouse)

time



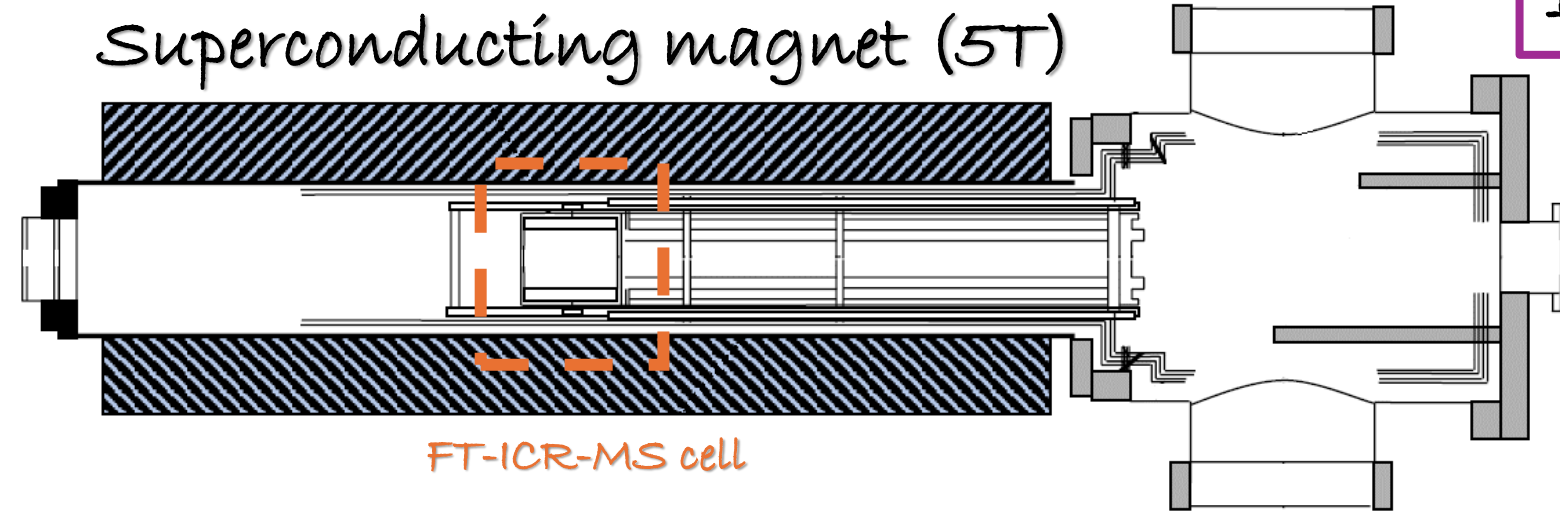
# PIRENEA SETUP



- $P \approx 10^{-10}$  mbar
- $T \approx 300$  K
- Long time scale  
( $\sim 1000$  s)

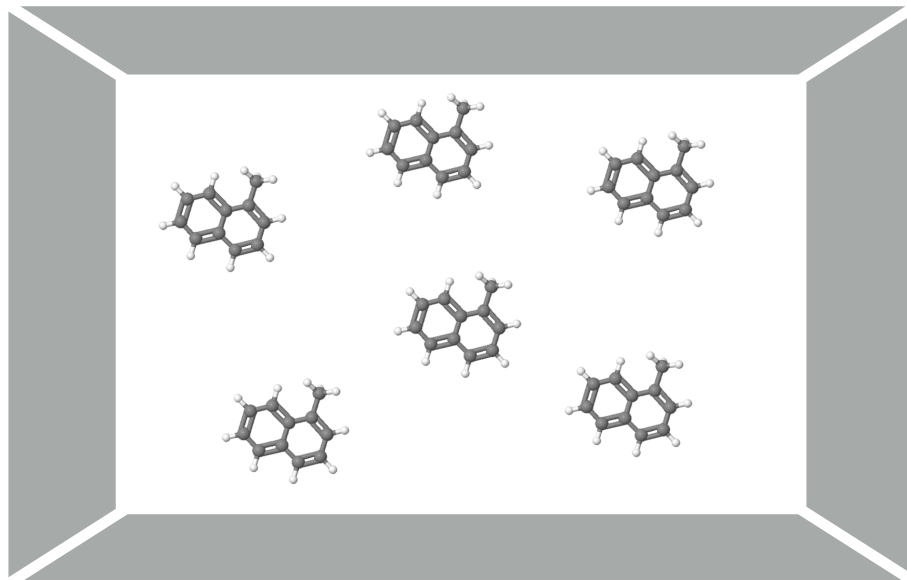


# PIRENEA SETUP



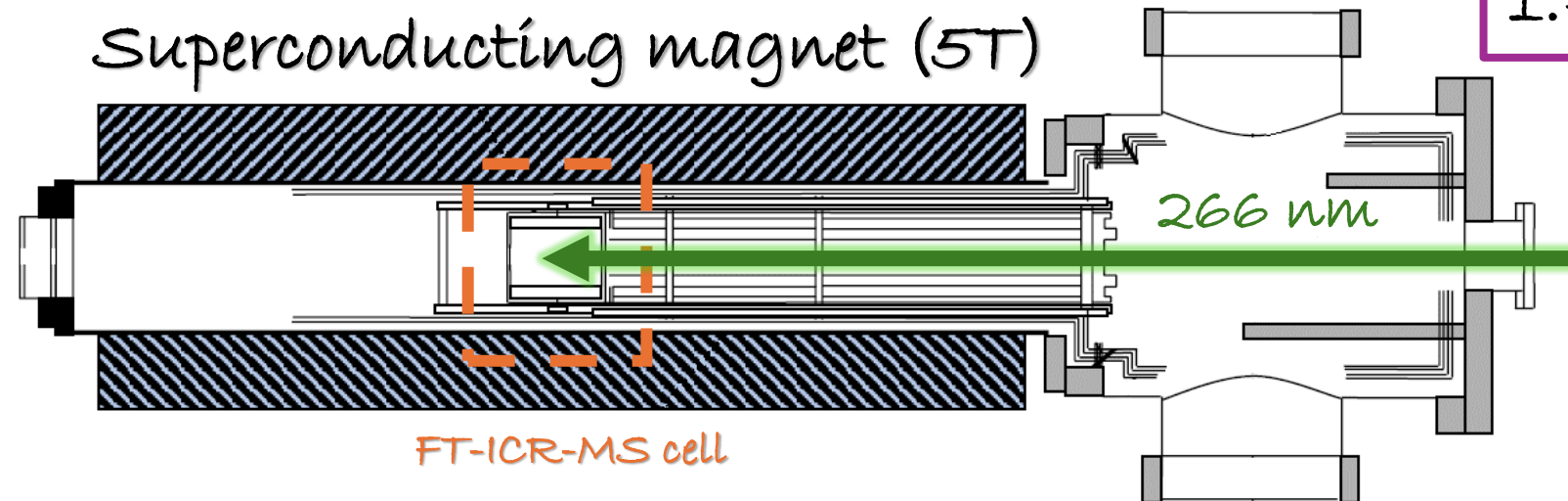
1. Production  $m/z$  141

A. neutral precursor



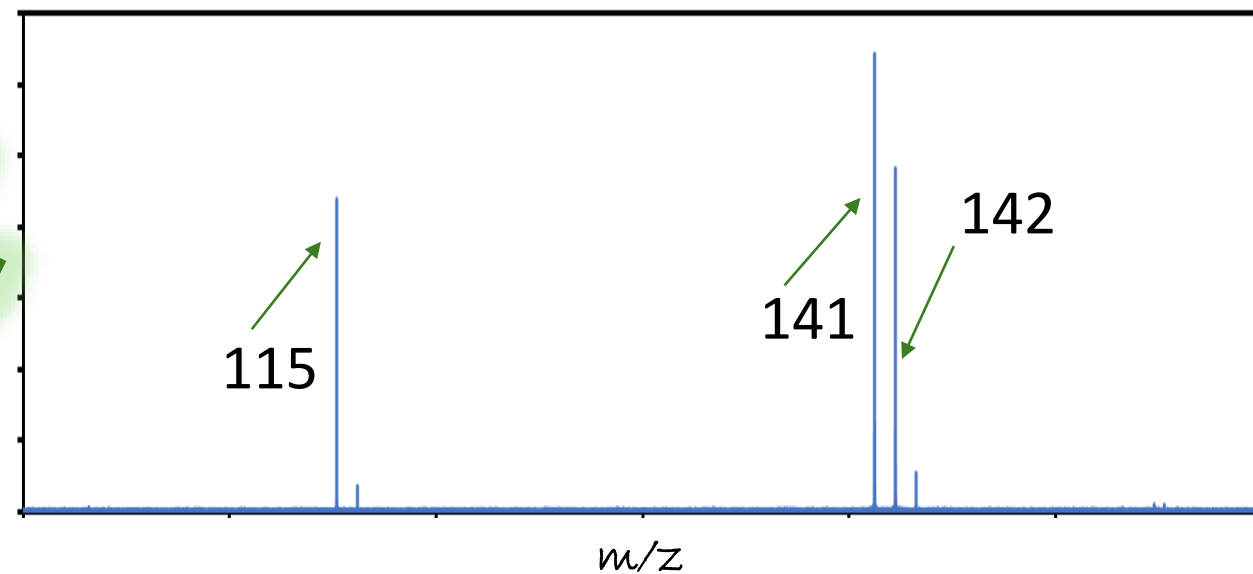
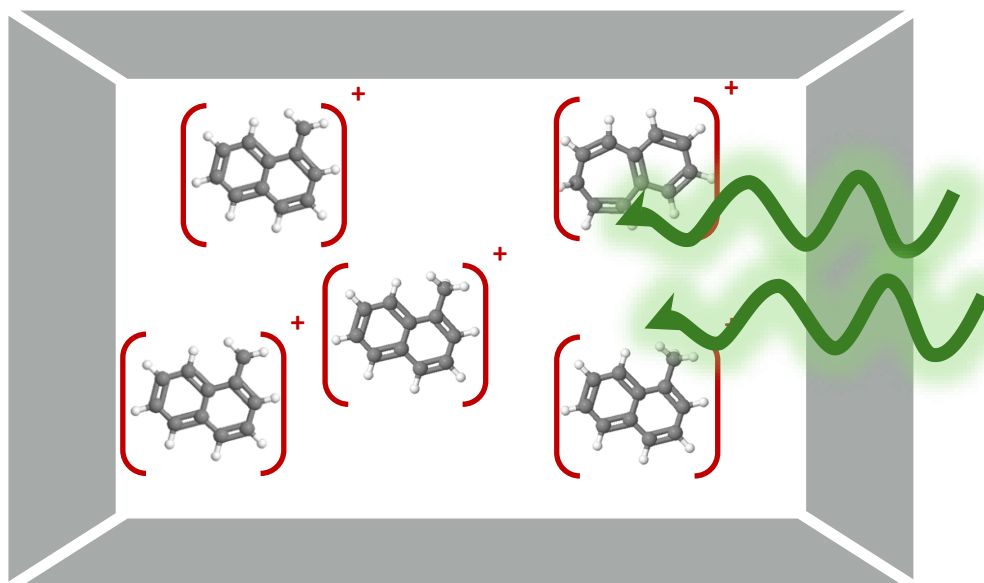
1-MeN/2-MeN  
(gaseous)

# PIRENEA SETUP

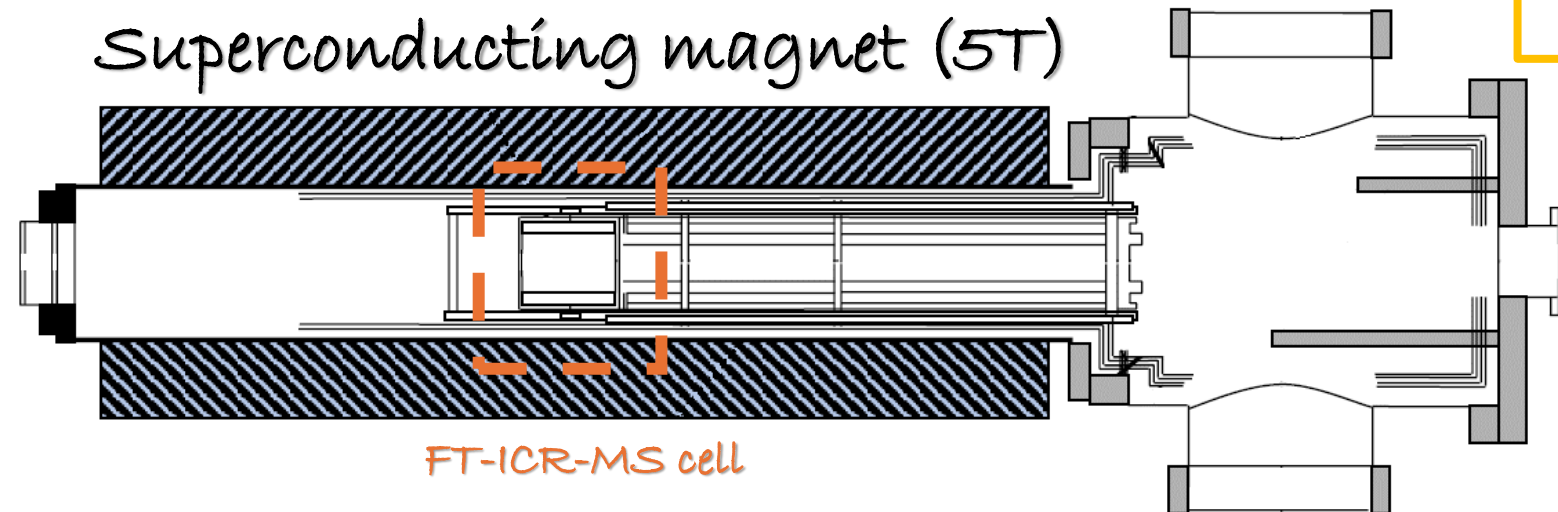


A. neutral precursor

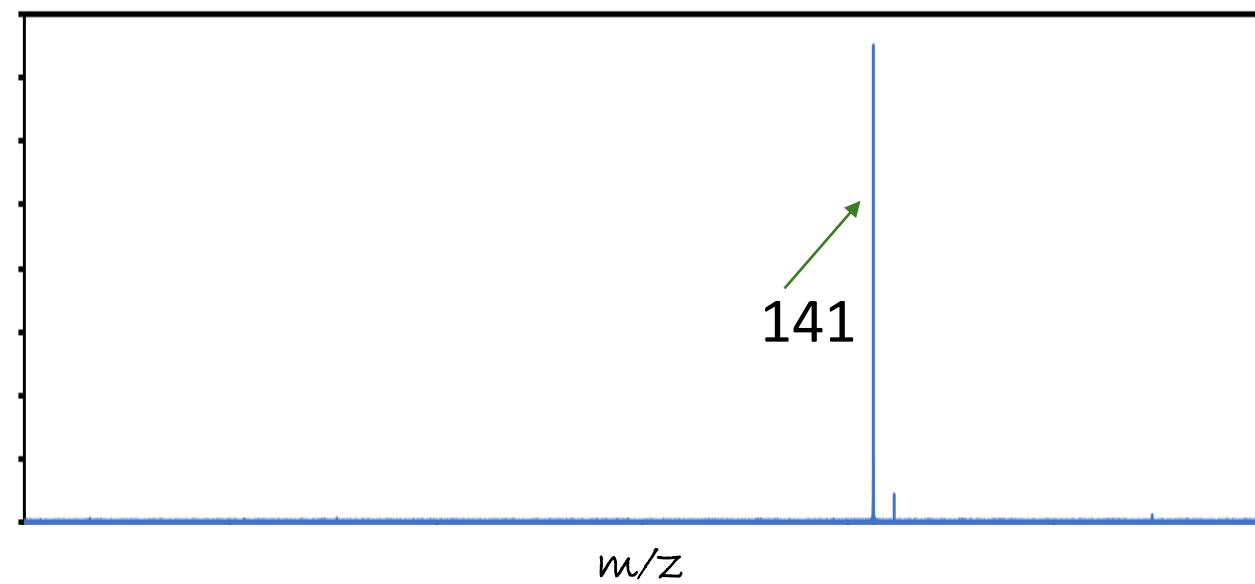
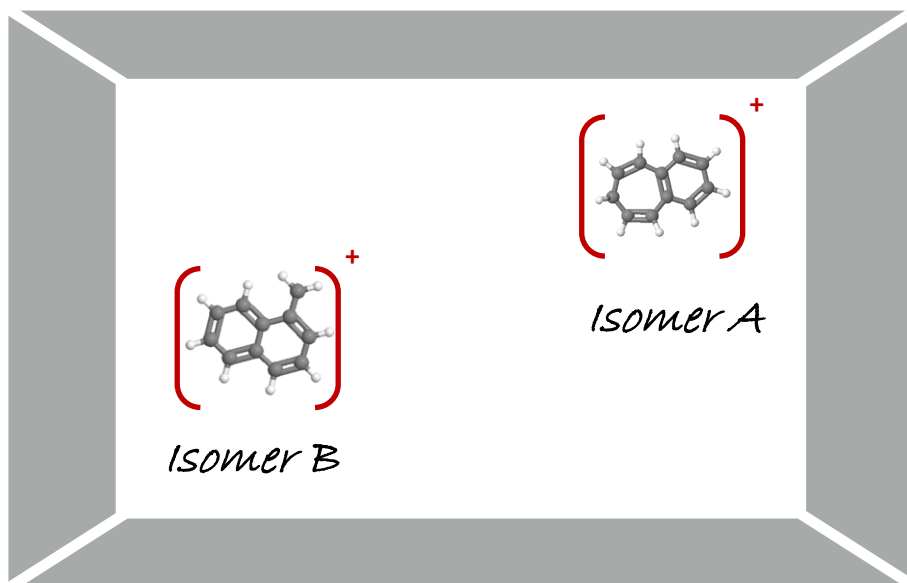
B. 266 nm Laser



# PIRENEA SETUP



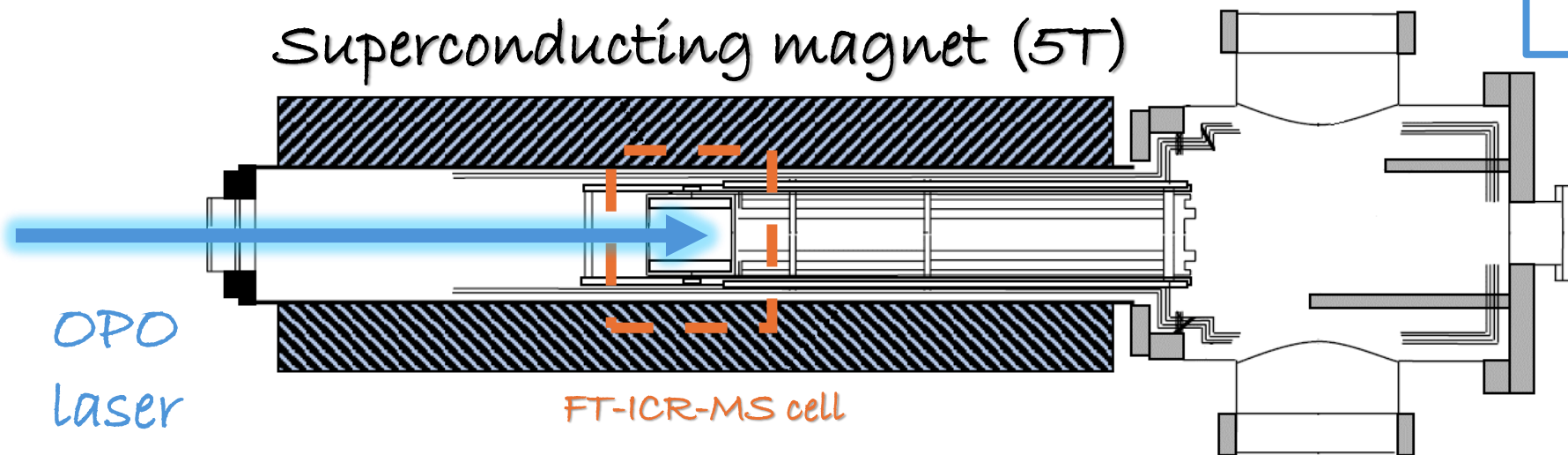
2. Isolation  $m/z$  141



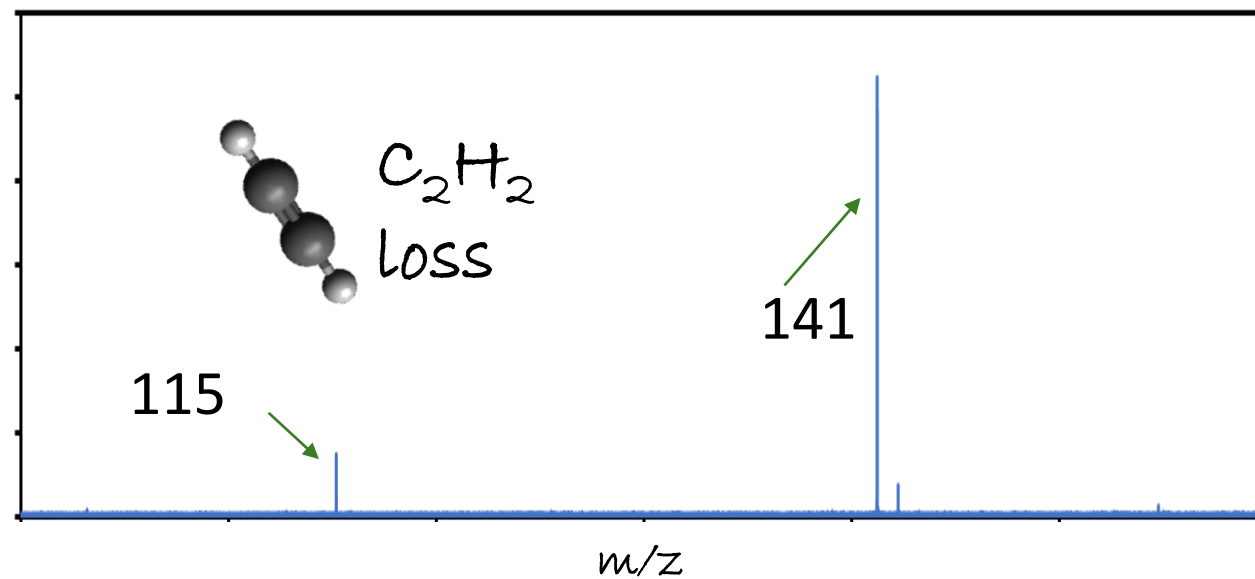
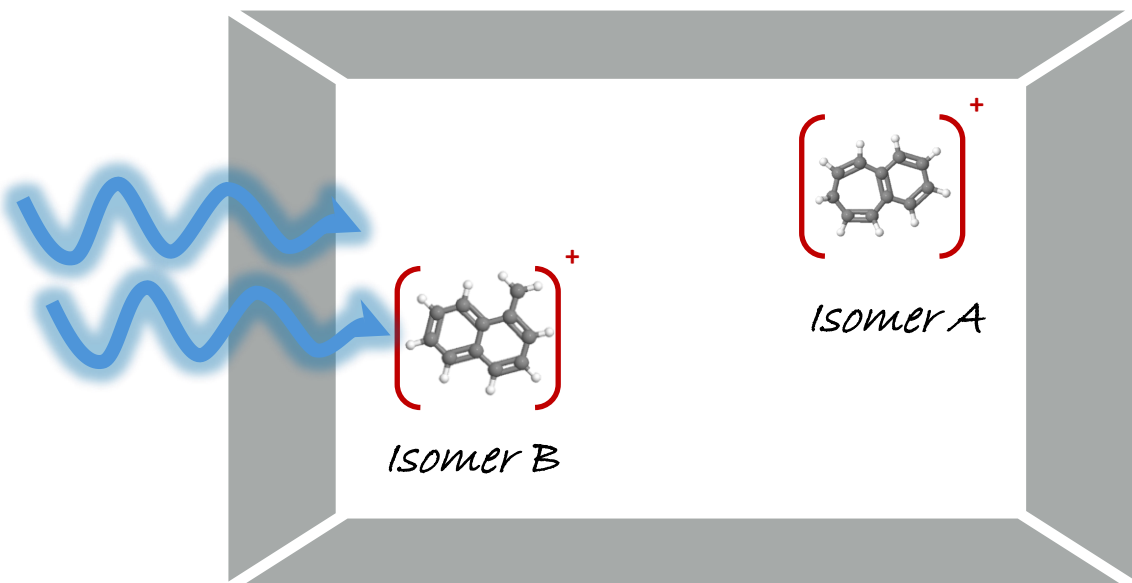
# PIRENEA SETUP

Superconducting magnet (5T)

3. Irradiation OPO

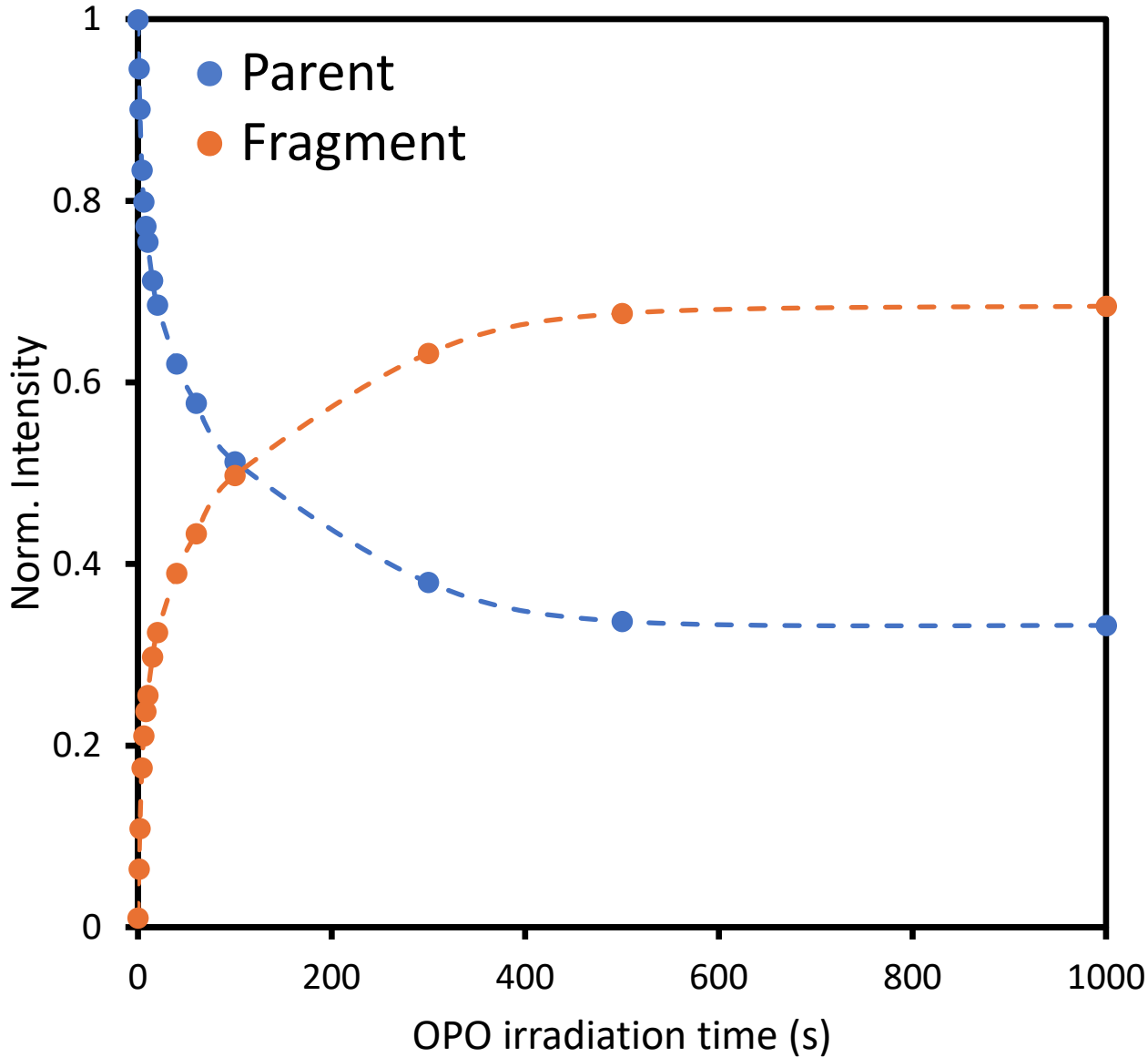


visible range

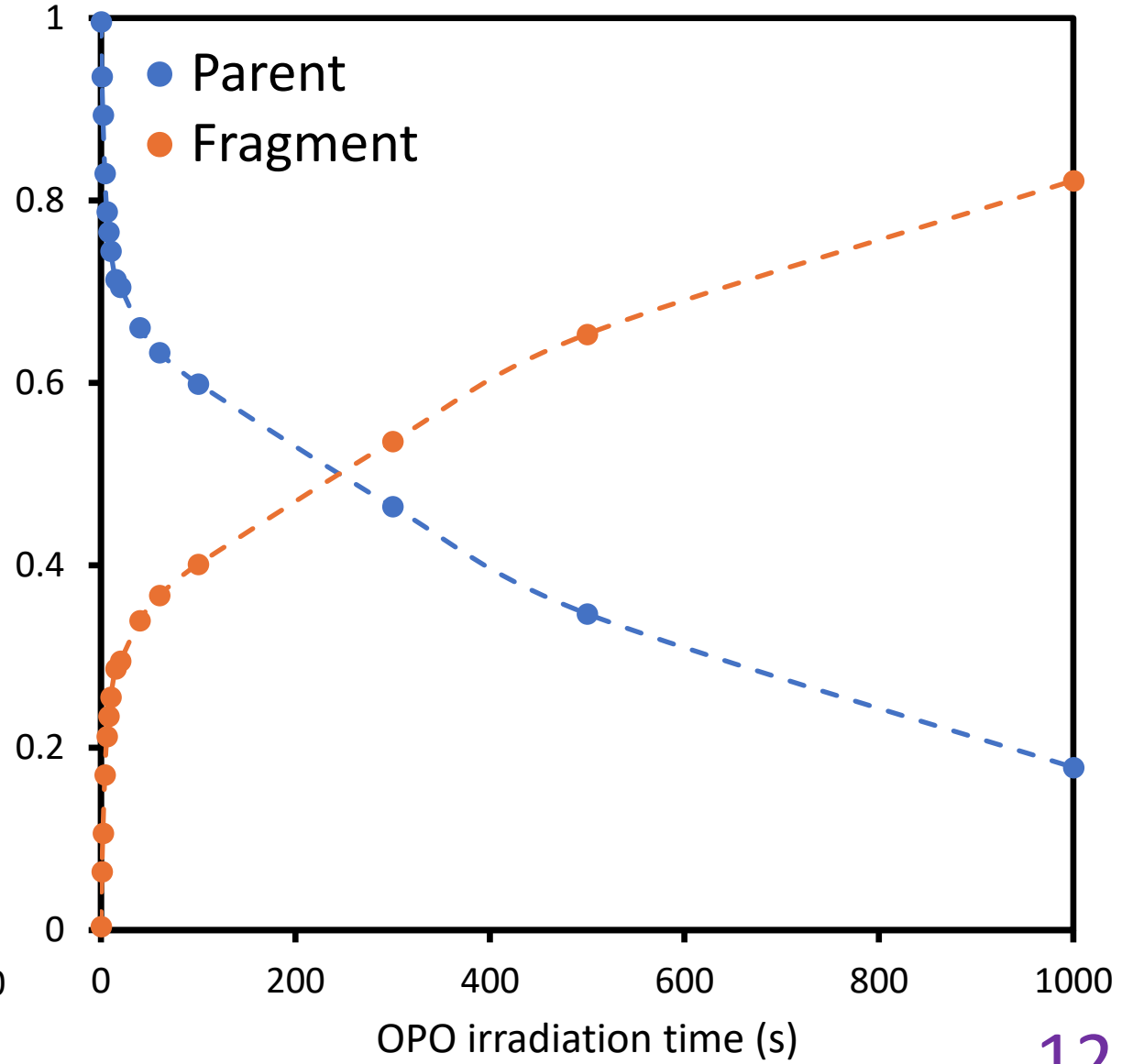


# PHOTOPROCESSING KINETIC CURVES

516 nm

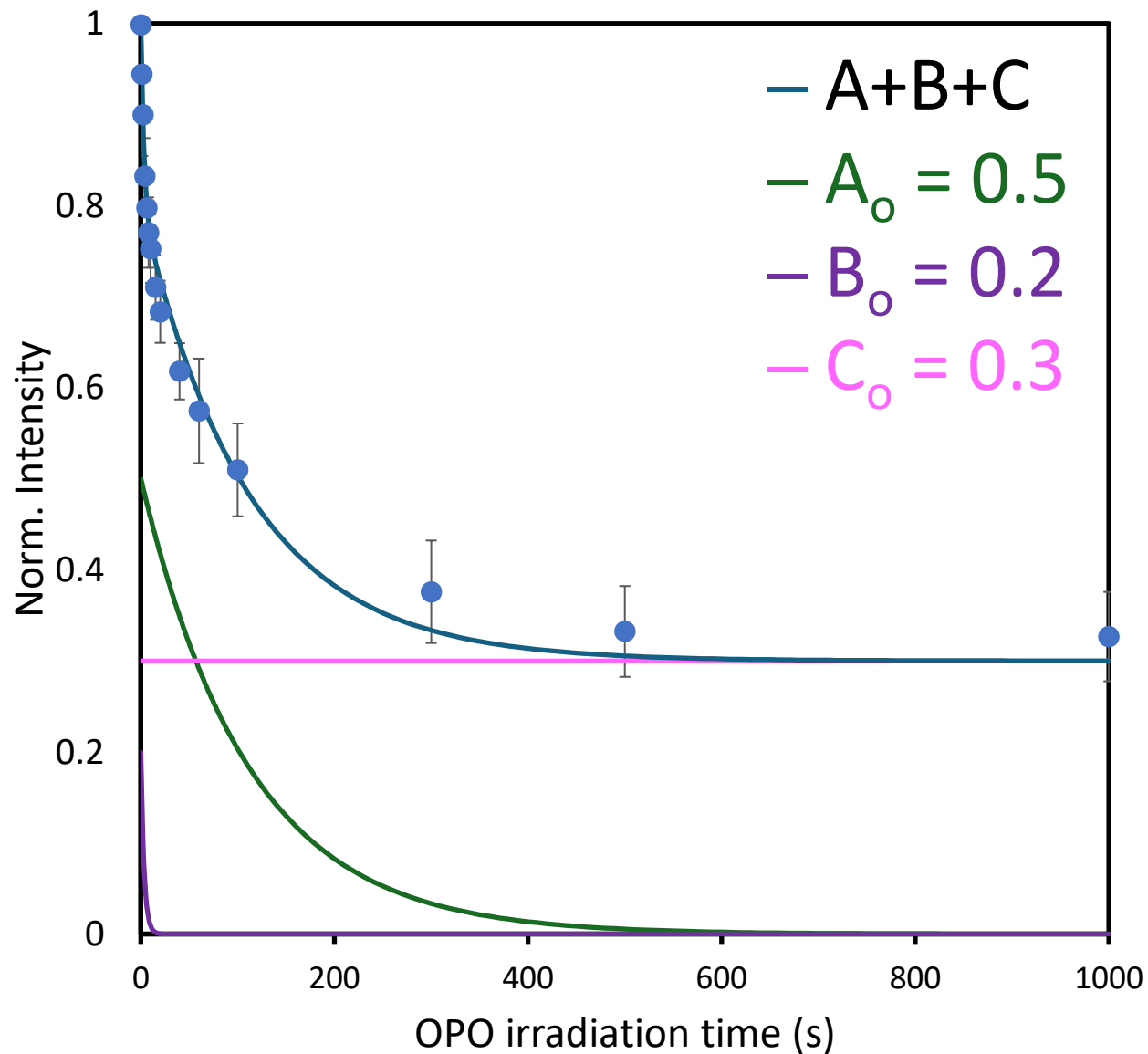


444 nm

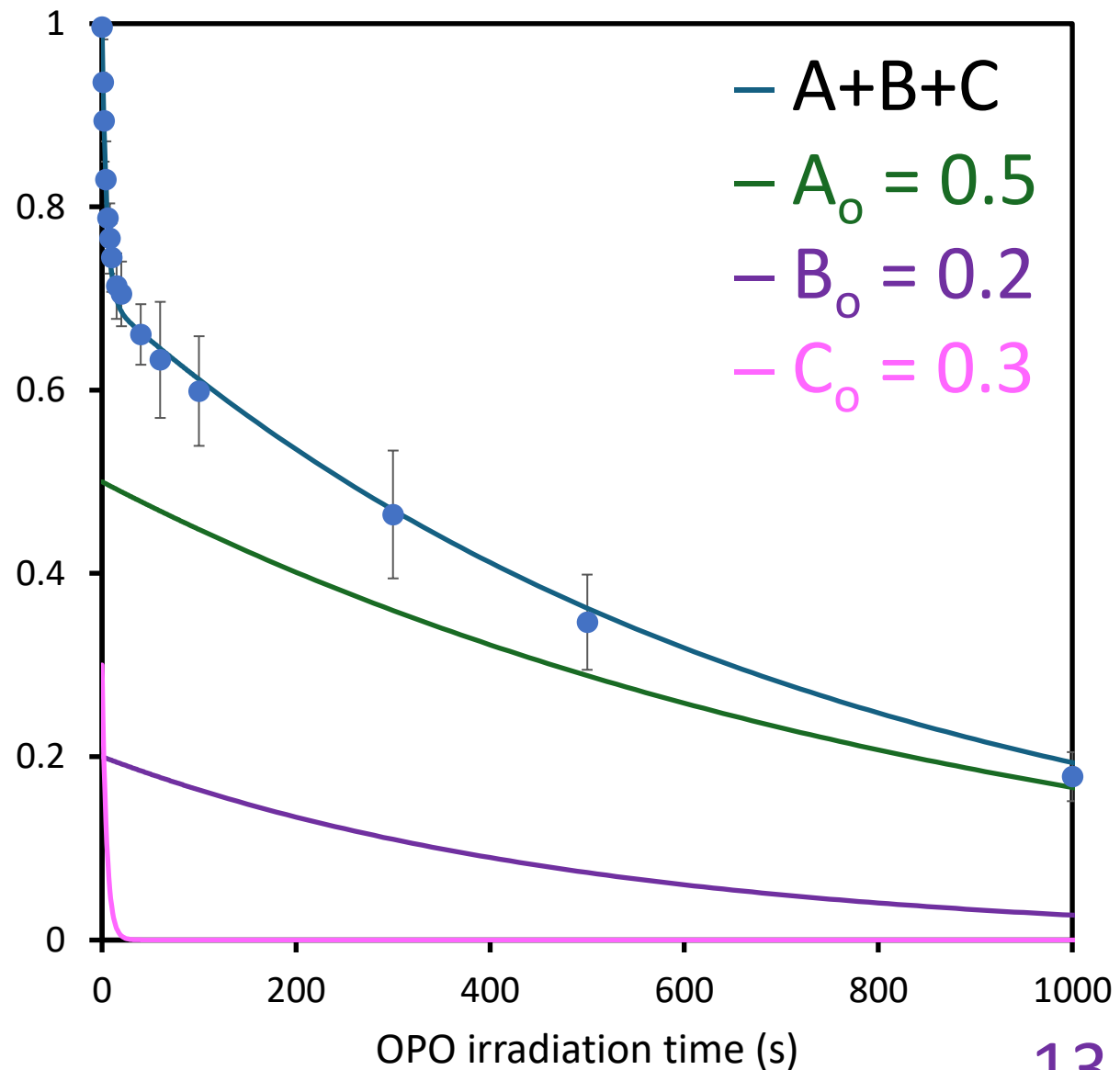


# MODELLING THE PHOTOPROCESSING KINETIC CURVES

516 nm



444 nm



# INITIAL POPULATION OF THE UNKNOWN ISOMERS



**2-MeN**

$A_o \approx 50\%$

$B_o \approx 20\%$

$C_o \approx 30\%$

**1-MeN**

$A_o \approx 30\%$

$B_o \approx 40\%$

$C_o \approx 30\%$

# REACTIVITY

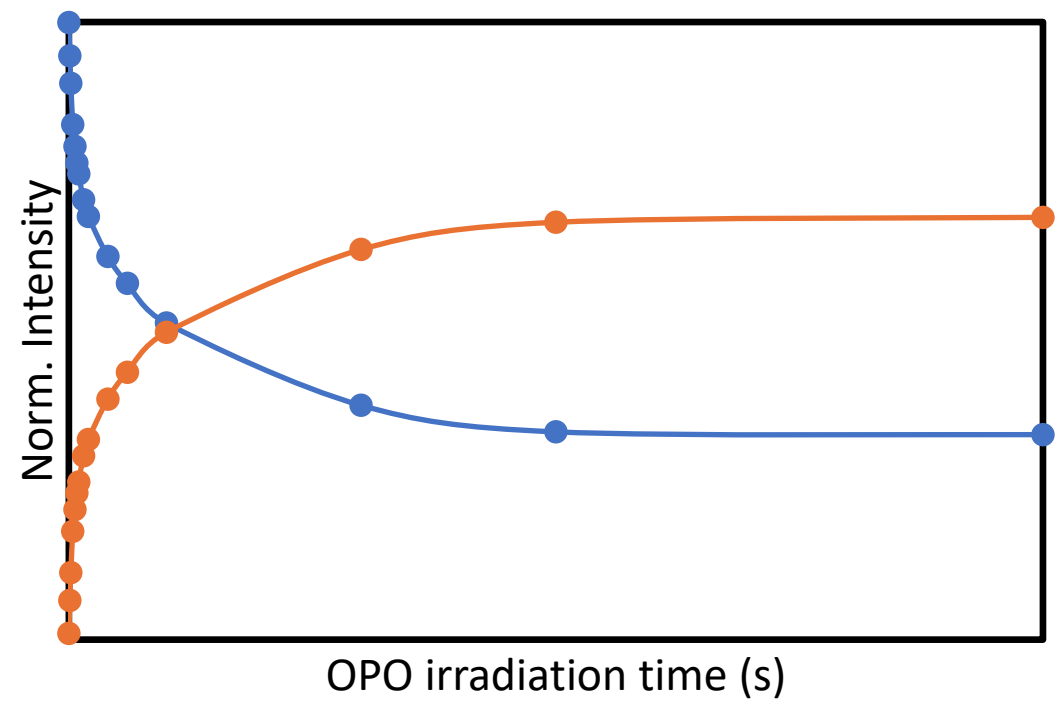
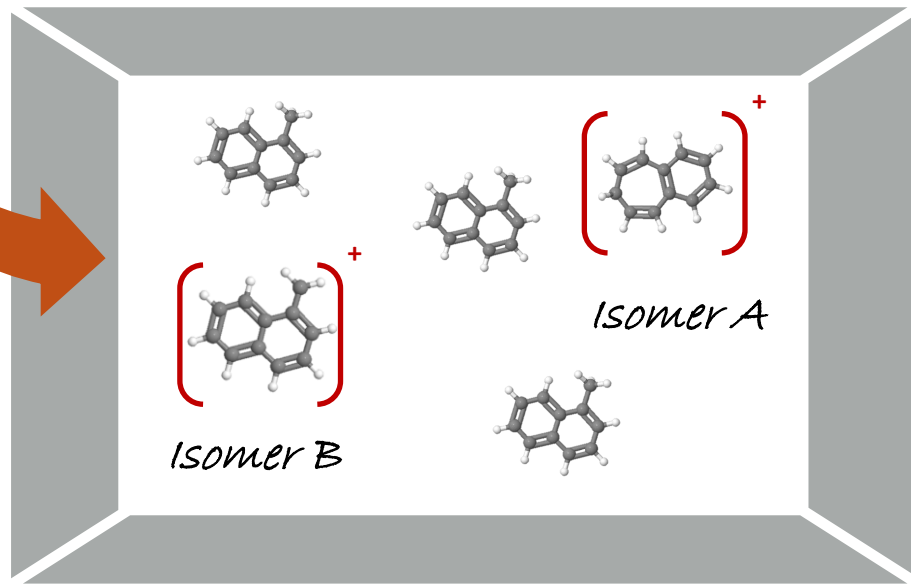
1. Production  $m/z$  141

2. OPO laser

3. Isolation  $m/z$  141

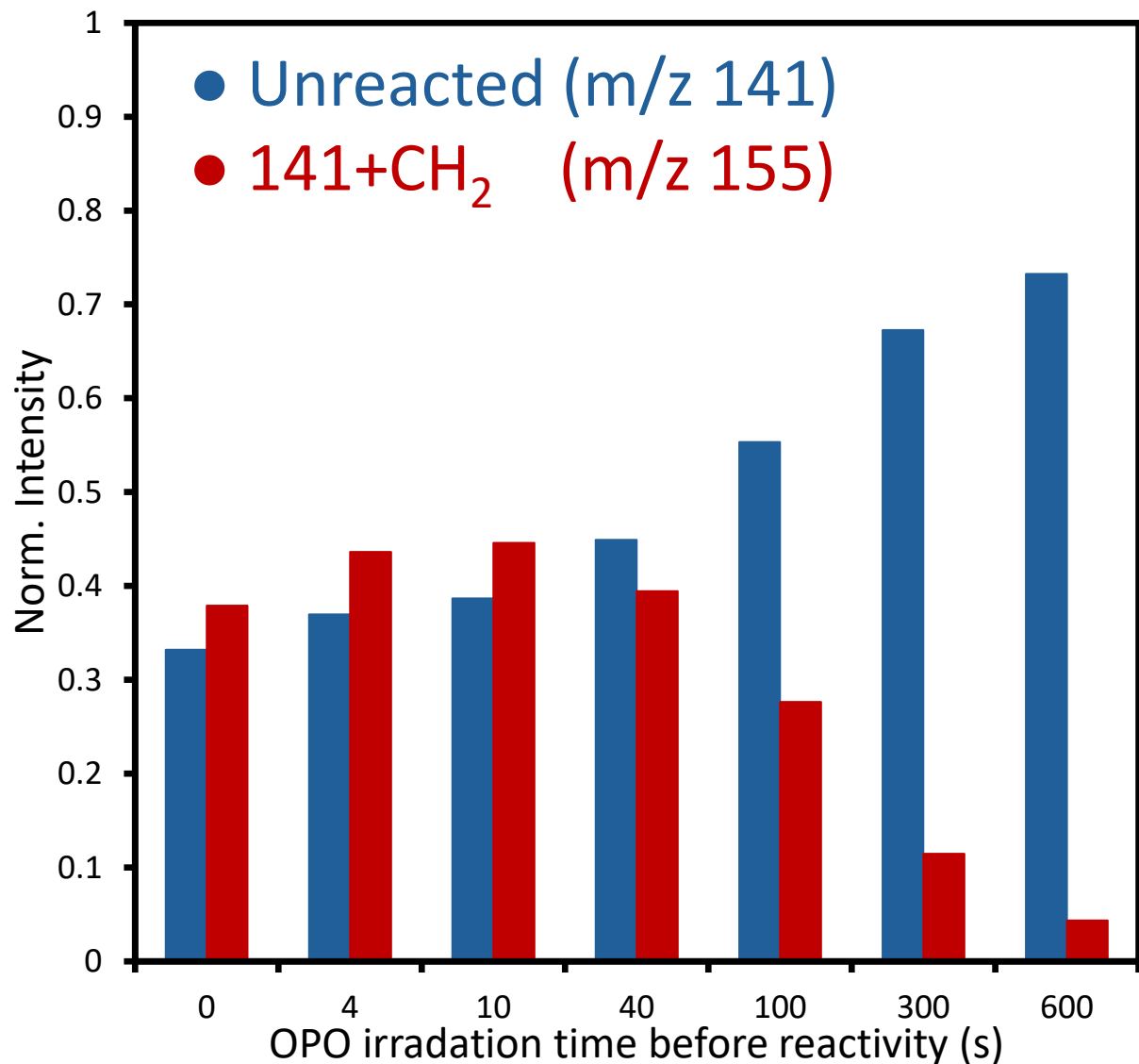
4. Reactivity

Information about the remaining population after OPO irradiation

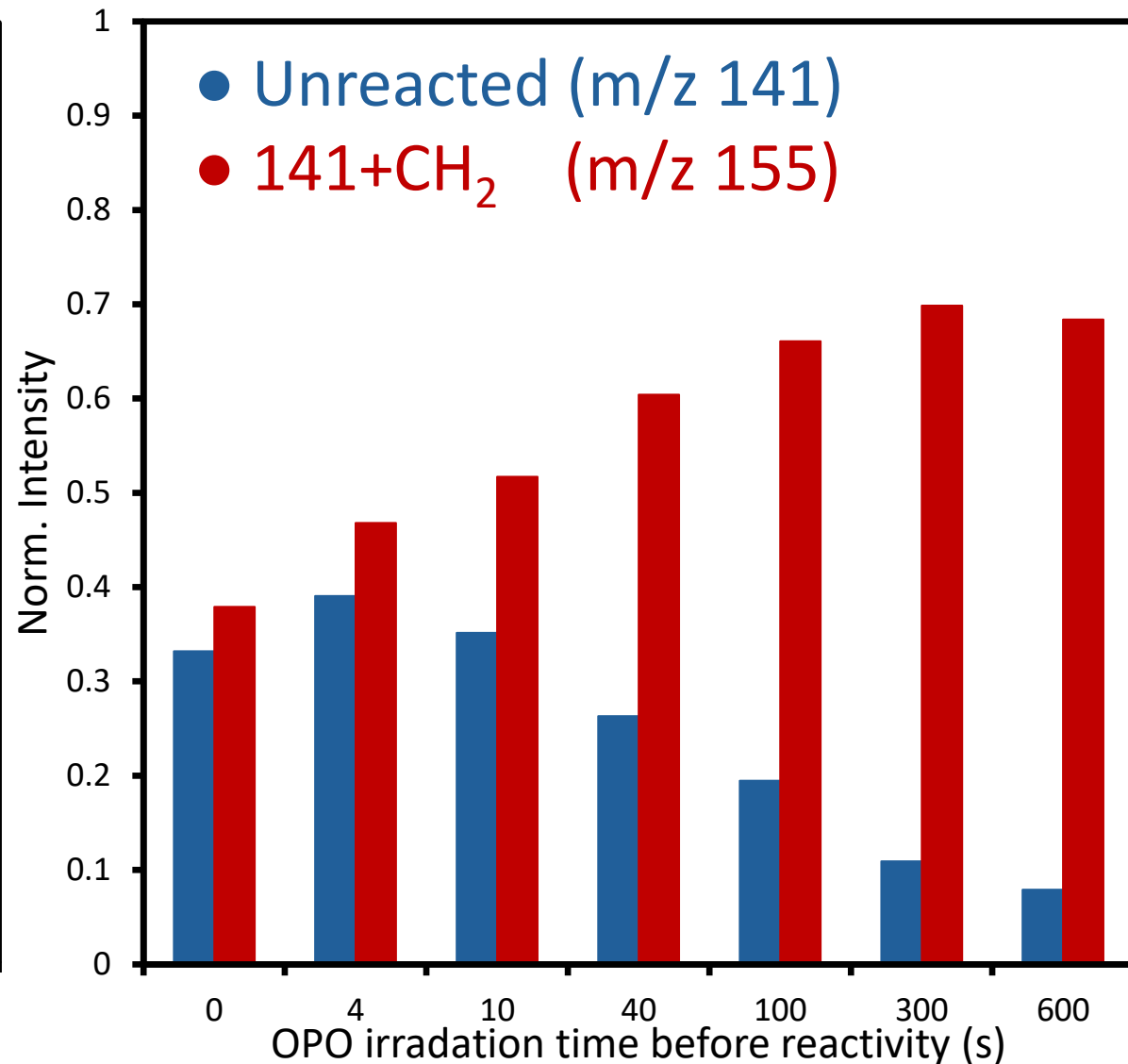


# REACTIVITY WITH 1-MeV

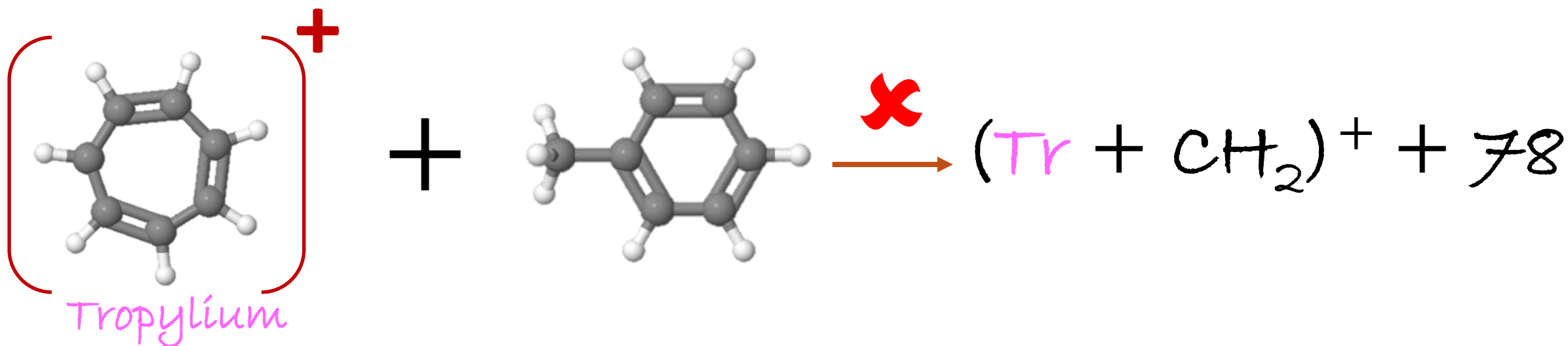
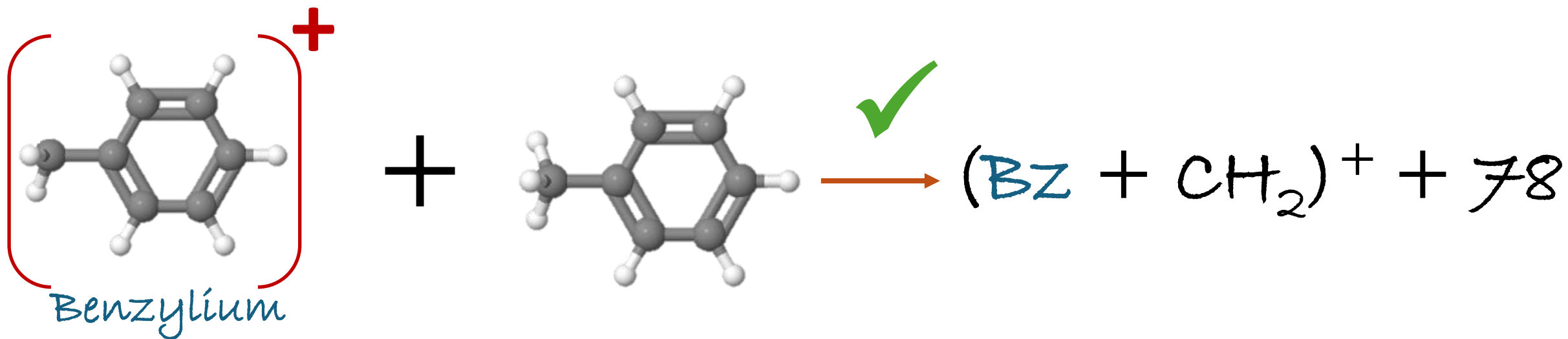
516 nm



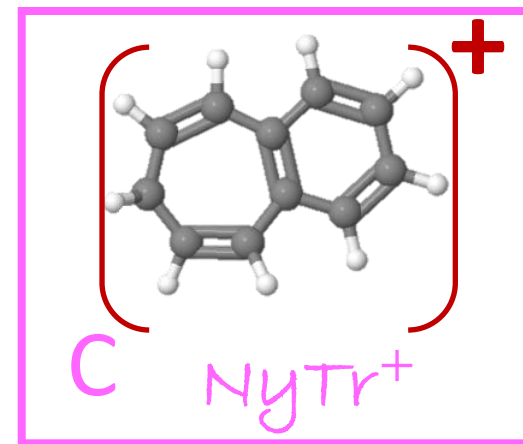
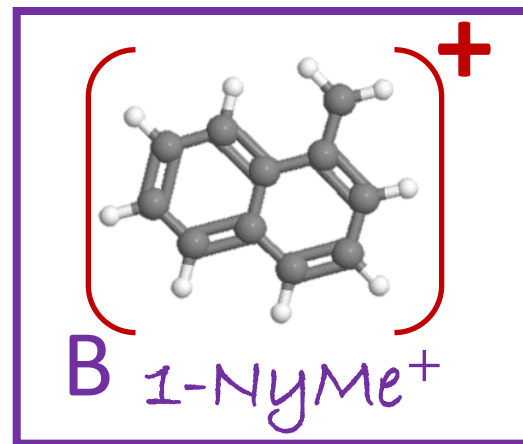
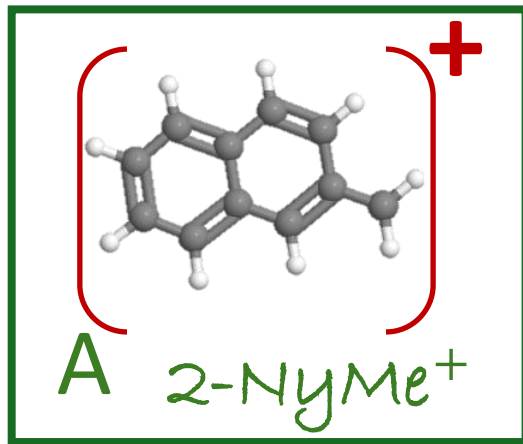
444 nm



# (TOLUENE-H) REACTIVITY



- Which are the long-lived isomers?



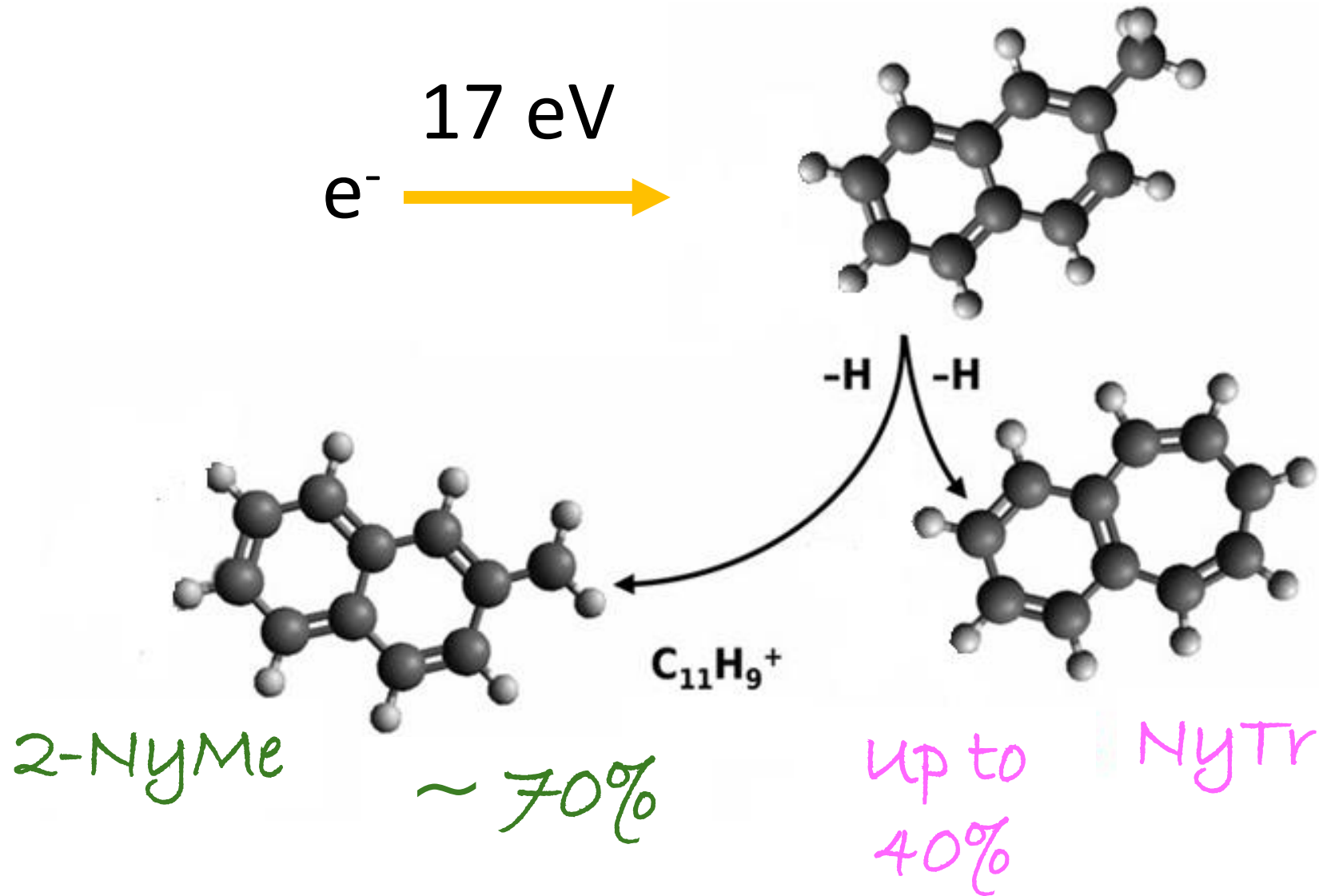
✓ NyTr does not absorb above 500 nm

~ 70 %

~ 30 %

# PIRENEA SUMMARY

Infrared spectroscopy of  $C_{11}H_9^+$  formed from 2-MN



- How fast does  $C_{11}H_9^+$  relax?

Mini-Ring (Lyon)

- Which are the long-lived isomers?

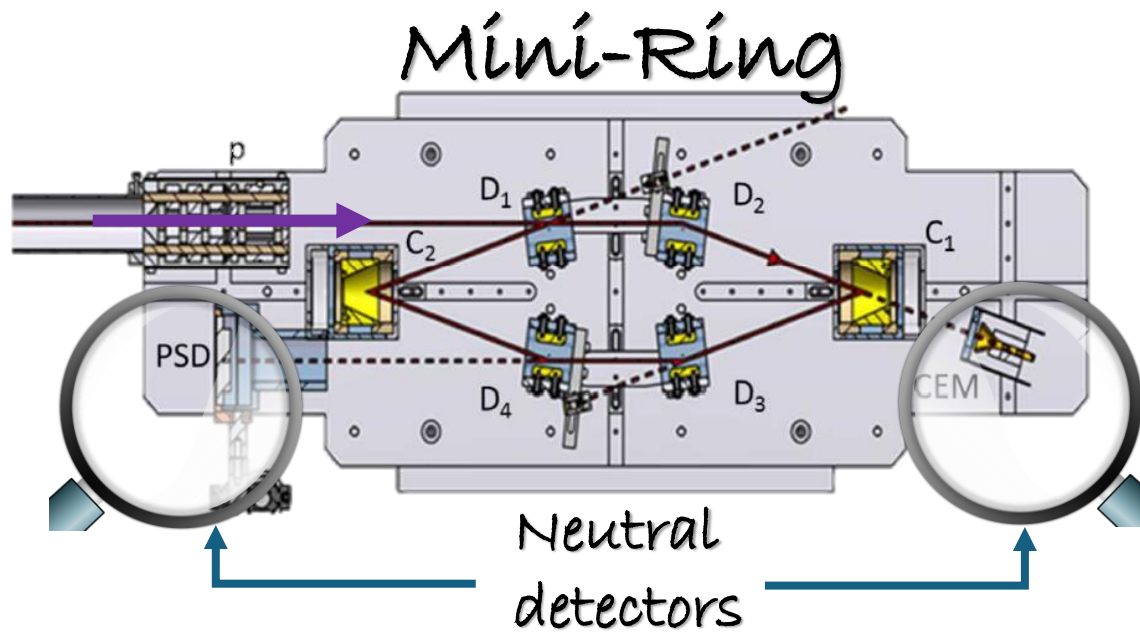
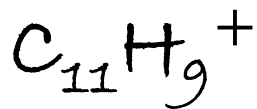
PIRENEA (Toulouse)

time

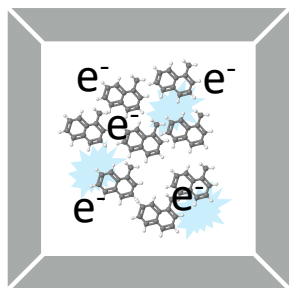


# Mini-Ring SETUP

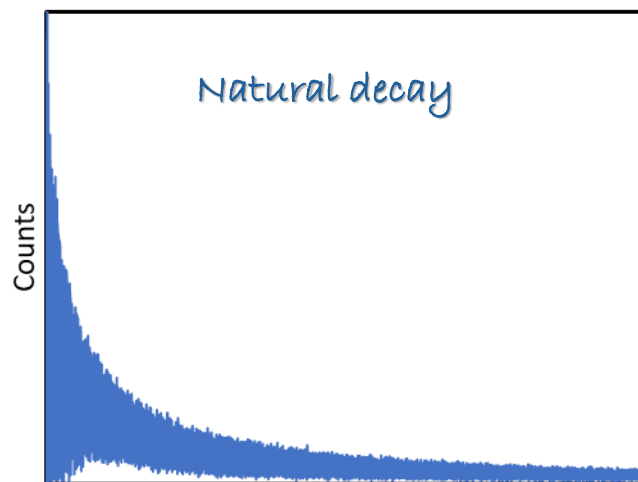
Magnetic sector



- $P \approx 10^{-10}$  mbar
- $T \approx 300$  K
- $T_{\omega} \approx 5.8 \mu$ s
- $KE \approx 12$  keV
- short time scale (30  $\mu$ s to 100 ms)



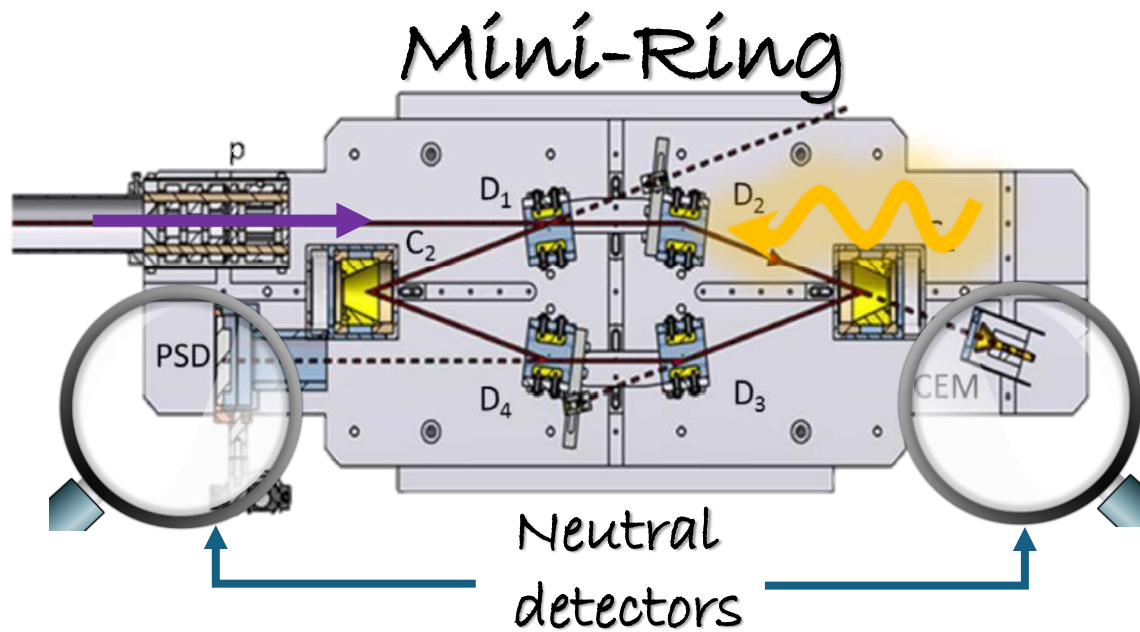
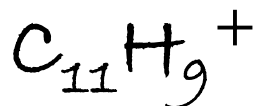
ECR ion source



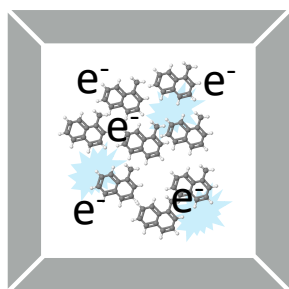
time

# Mini-Ring SETUP

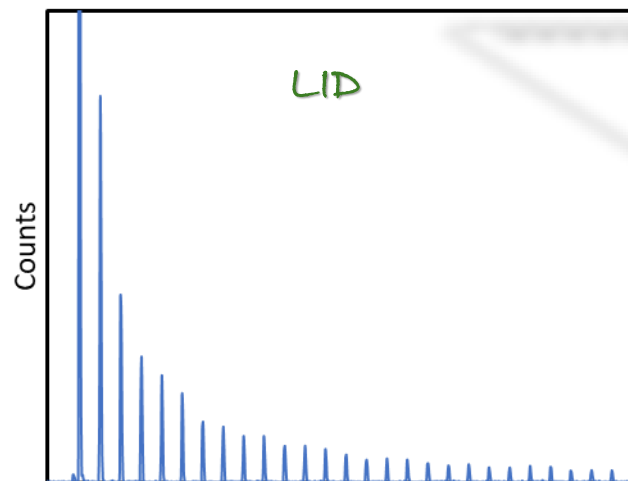
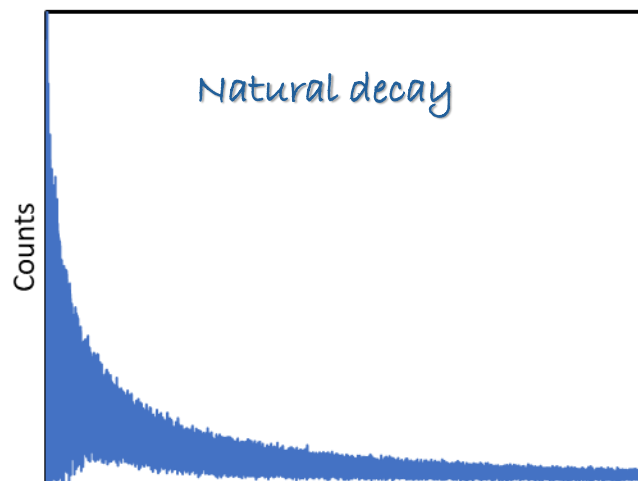
Magnetic sector



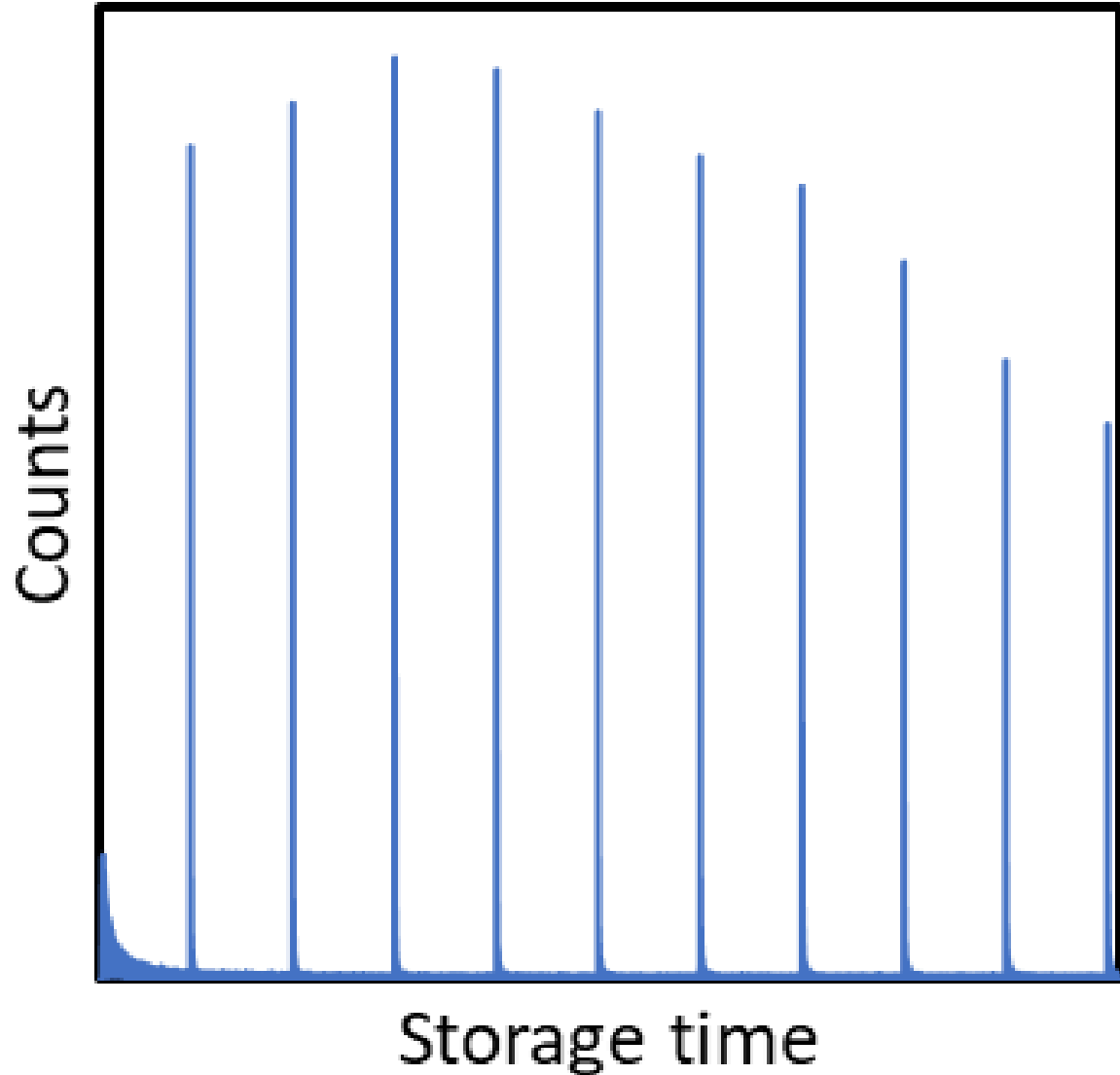
- $P \approx 10^{-10}$  mbar
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ECR ion source



time

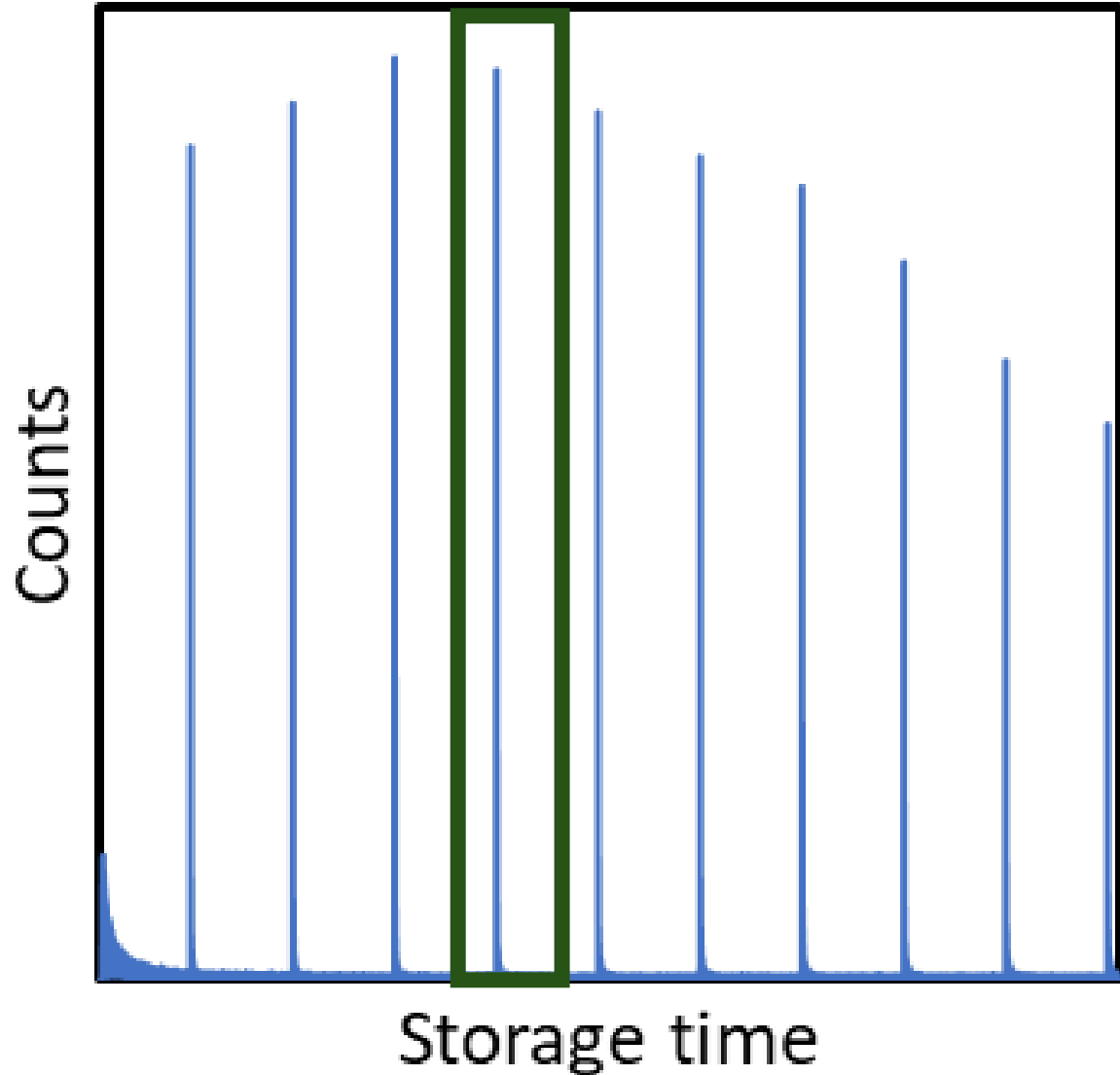


Storage time

100 ms

10 laser shots

(100Hz)



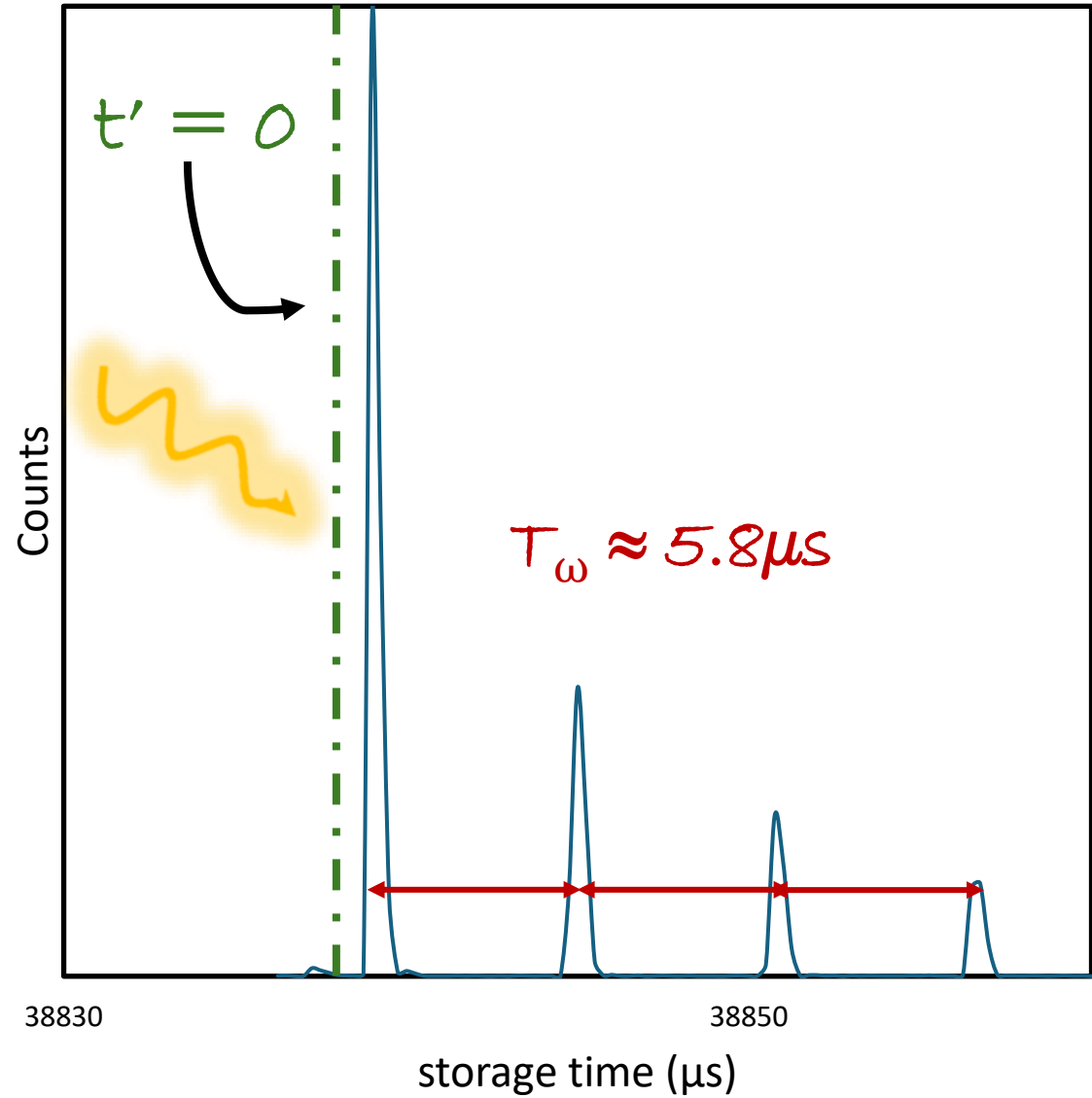
Storage time

100 ms

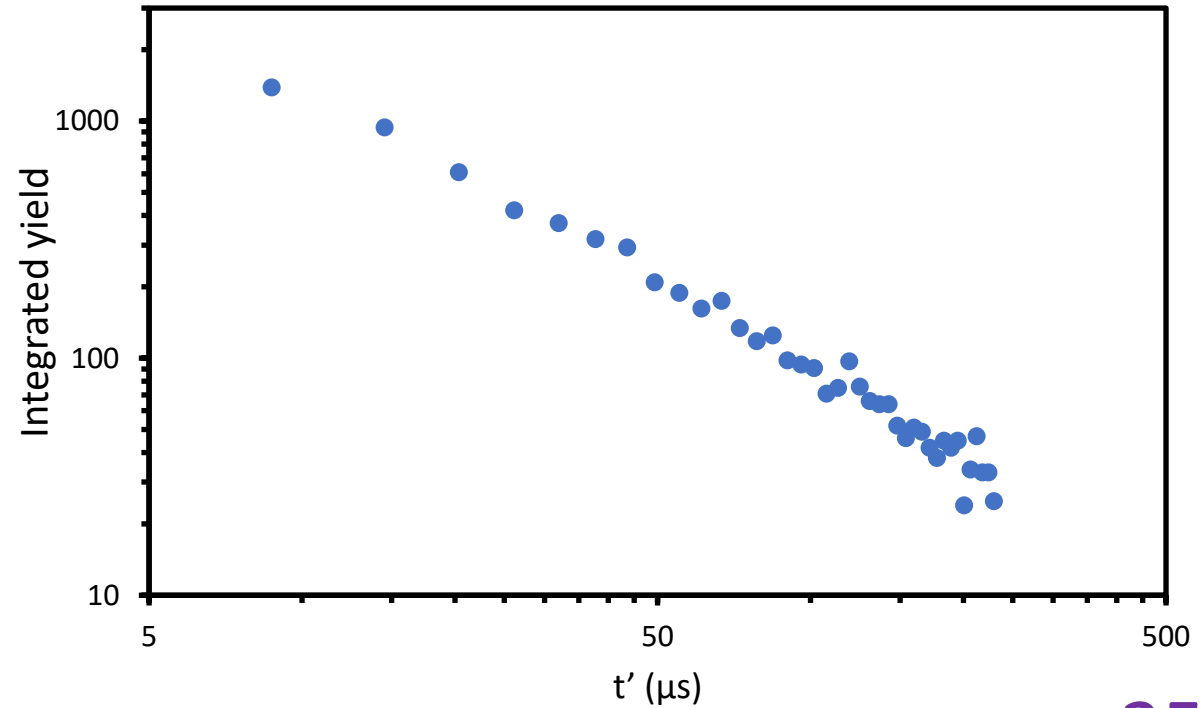
10 laser shots

(100Hz)

# TIMES IN Mini-Ring



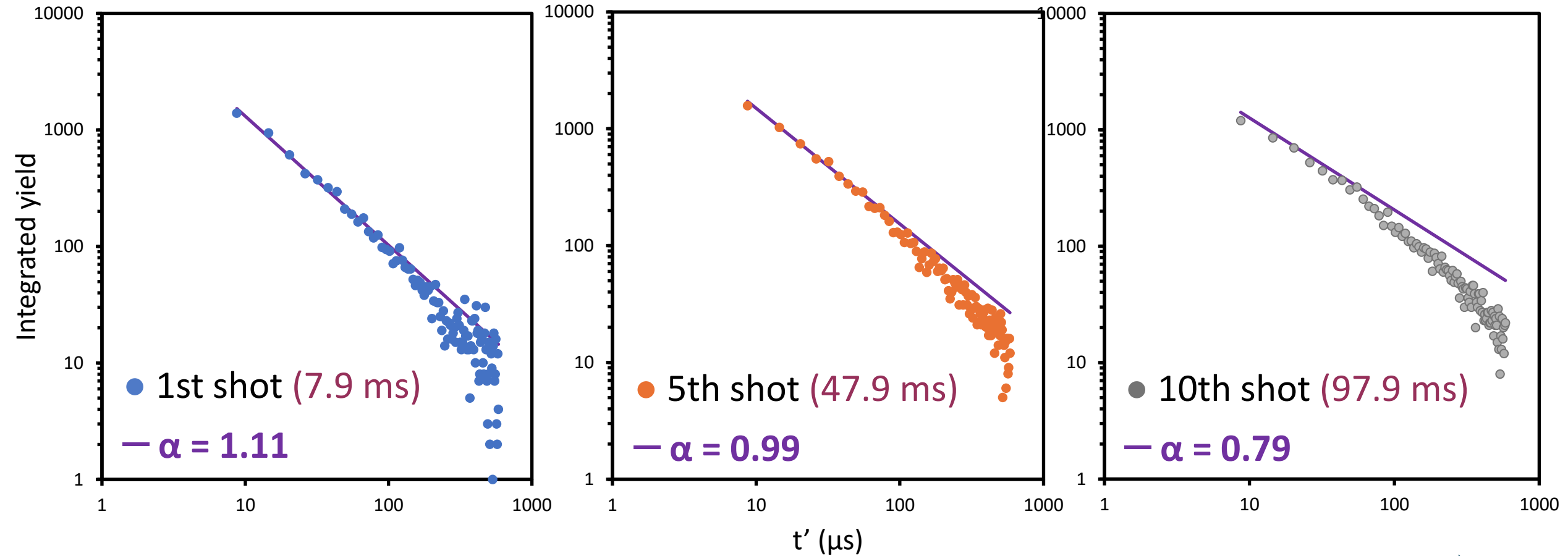
$t'$ : time after laser firing  
 $\mu\text{s}$



# INTEGRATED YIELD: POWER LAW FIT

$$t^{-\alpha}$$

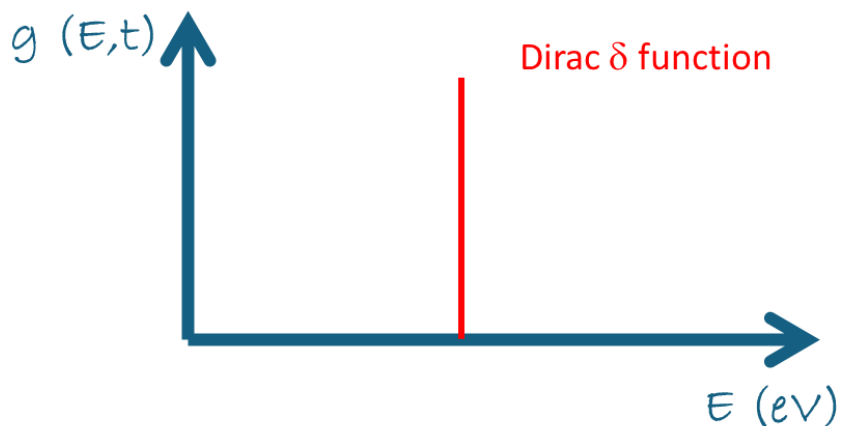
Fitting the 10 first peaks for 350nm



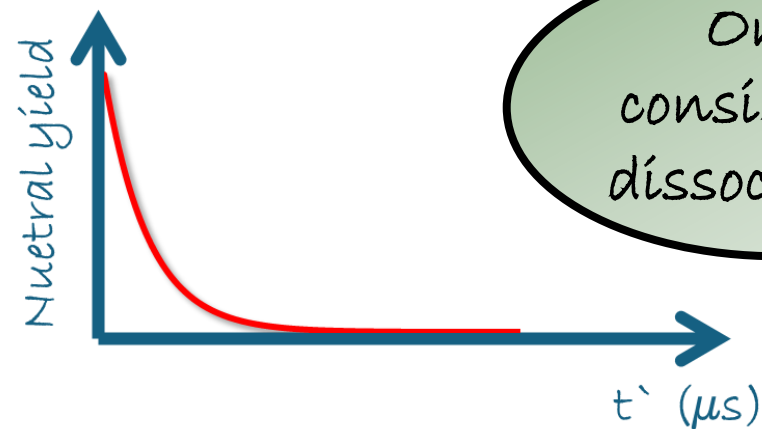
$\alpha$  decreasing

# INTEGRATED YIELD: POWER LAW FIT

- Ion ensemble with infinitely narrow Internal Energy Distribution (IED)

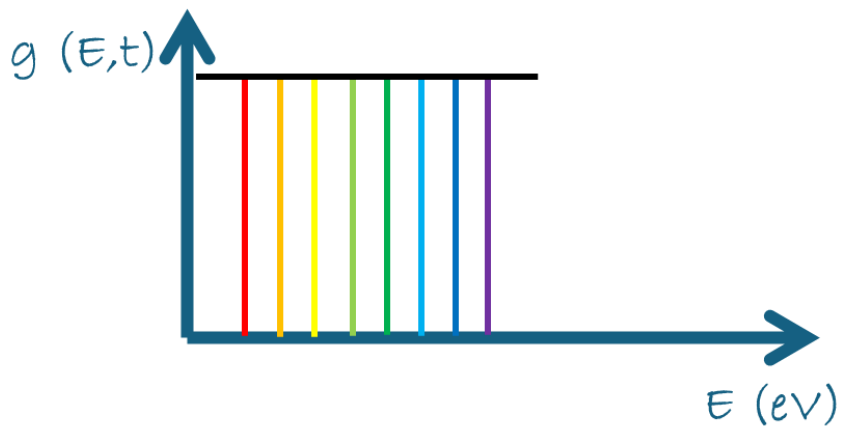


$$N(t) = N_0 \exp(-k_D t)$$

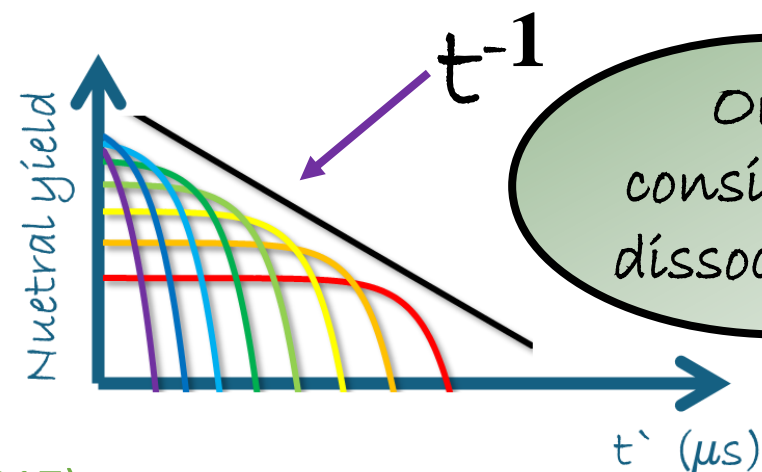


Only considering dissociation!

- Ion ensemble with an infinitely broad IED



$$N(t) = N_0 t^{-1}$$



Only considering dissociation!

Ji et al. J. Chem. Phys. (2017)

- How fast does  $C_{11}H_9^+$  relax?
  - ✓ Cooling slower than for similar molecules
  - ✓ Dissociation is quenched in the 100 ns range for our IED
    - ↳ Recurrence fluorescence and/or isomerization



- *Aim:* relaxation dynamics of Astro-PAHs
- *Methods:* coupling a cryogenic electrostatic storage ring to the DESIRS VUV beamline at SOLEIL
- *Envisioned investigations:*
  - ✓ To more closely mimic PDR environments
  - ✓ IR emission
  - ✓ To provide experimental dissociation rates
  - ✓ To provide experimental RF rates

# SPECIAL THANKS!

Christine Joblin

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Aude Simon

Jérôme Bernard

Suvasthika Indrajith

Pavol Jusko



Laboratoire de Chimie et Physique Quantiques



Toulouse



Lyon



München





UNIVERSITÉ  
TOULOUSE III  
PAUL SABATIER



# Thanks for your attention!

