Momentum imaging experiments on photo double ionization of atoms by XUV laser sources.

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LCAM	**D. Dowek and co.**
SPAM	**B. Carré and co.**
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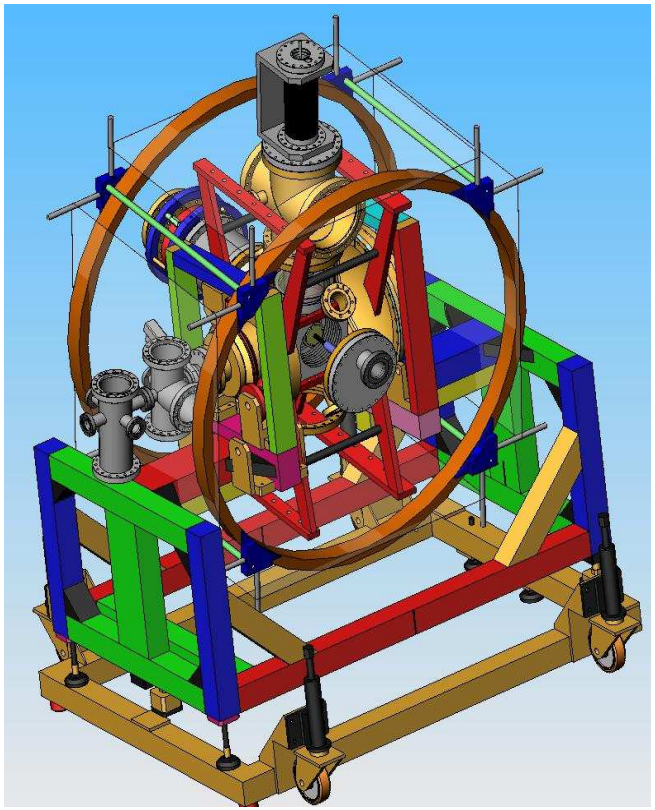
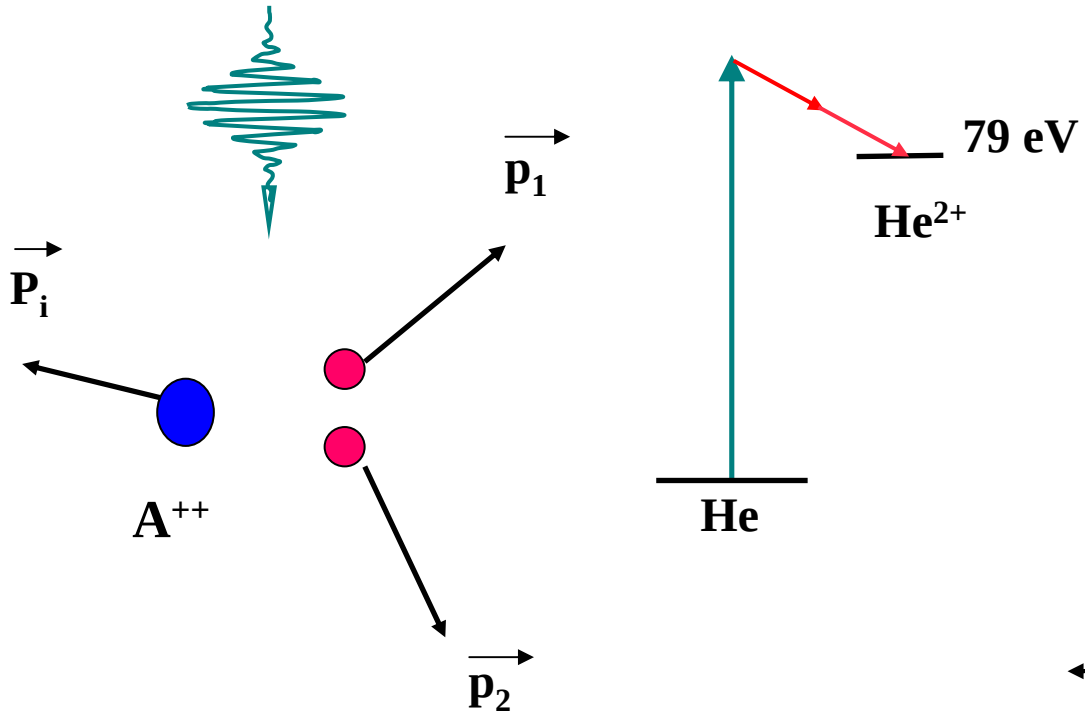
Harmonic generation 1 kHz
PLFA (Saclay) - CIEL2

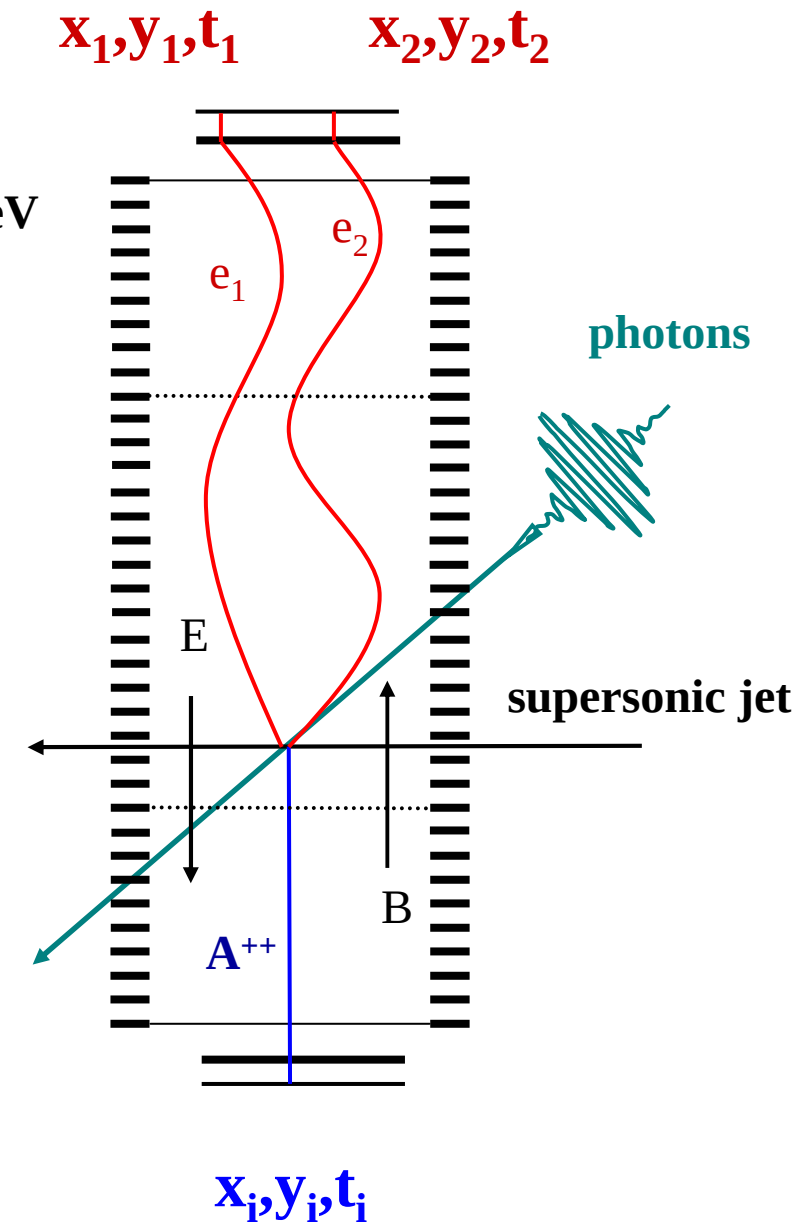


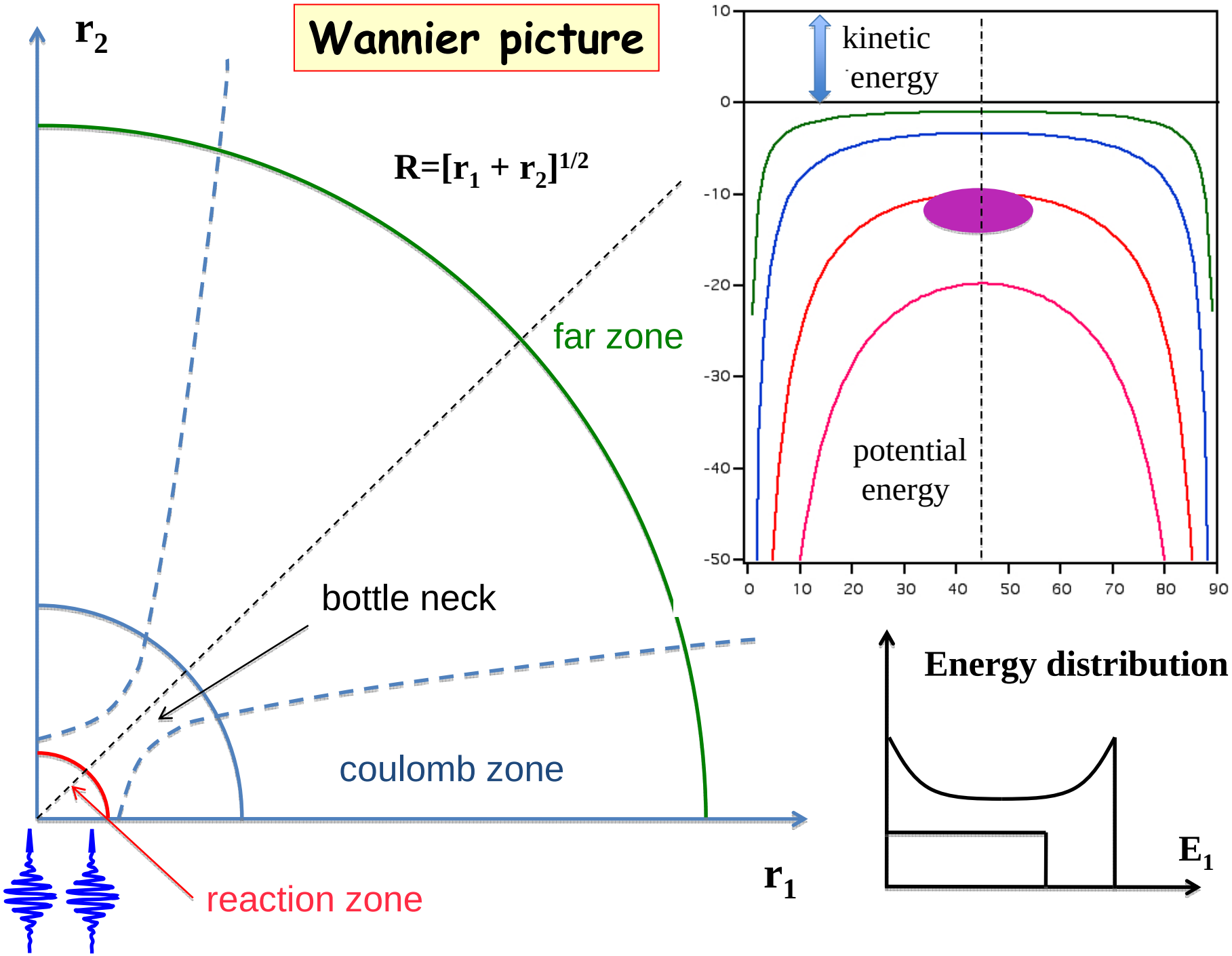
PDI -Momentum imaging



$$\vec{p}_1 + \vec{p}_2 + \vec{P}_i = 0$$

- **[e – A^{++}] coincidences (COLTRIMS)**
- **[e – e] coincidences**



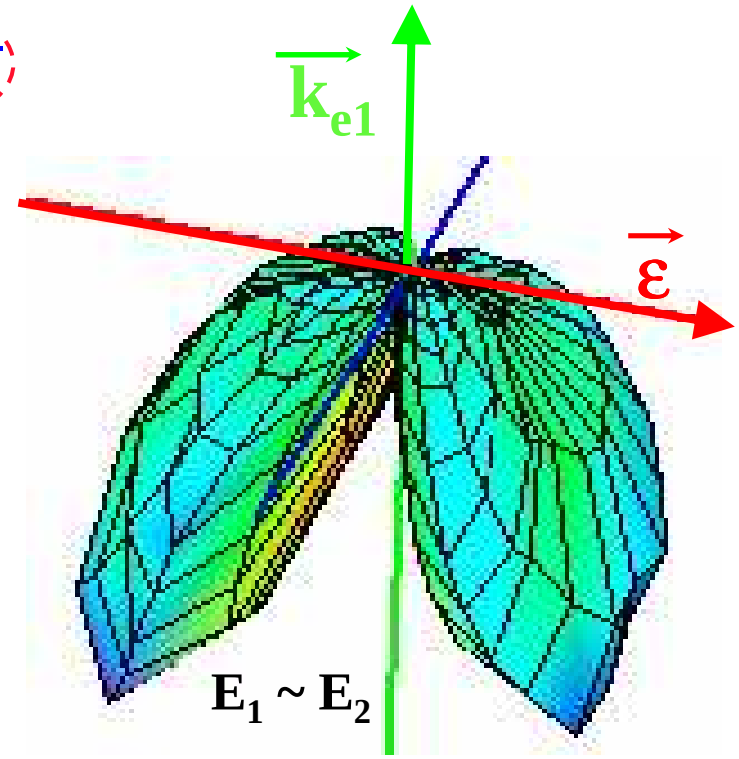

Wannier picture
r2
R=[r1 + r2]1/2
far zone
bottle neck
coulomb zone
reaction zone
r1
kinetic
energy
potential
energy
10
0
-10
-20
-30
-40
-50
0
10
20
30
40
50
60
70
80
90
Energy distribution
E1

PDI of helium - 1 XUV photon – synchrotron

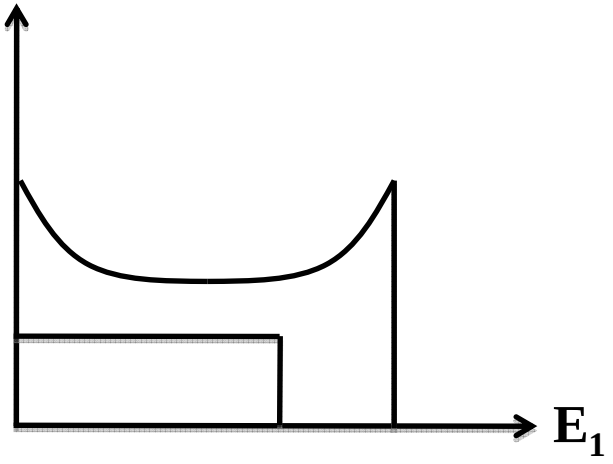
$h\nu + He \Rightarrow He^{2+} + e^- + e^-$

104 eV

Repetition rate 10 MHz



Energy distribution



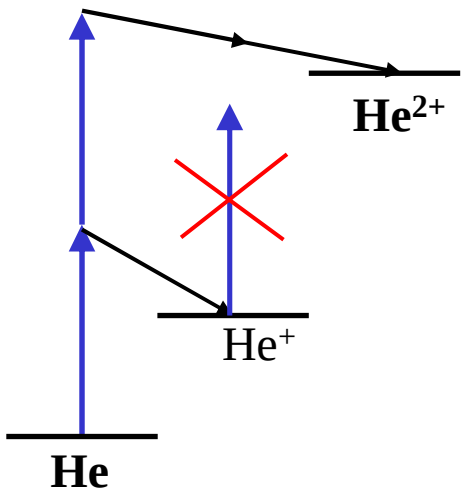
Number of events ~ 10^6

recording ~ 5 h ELETTRA

Non sequential PDI of helium - 2 XUV photons - FLASH

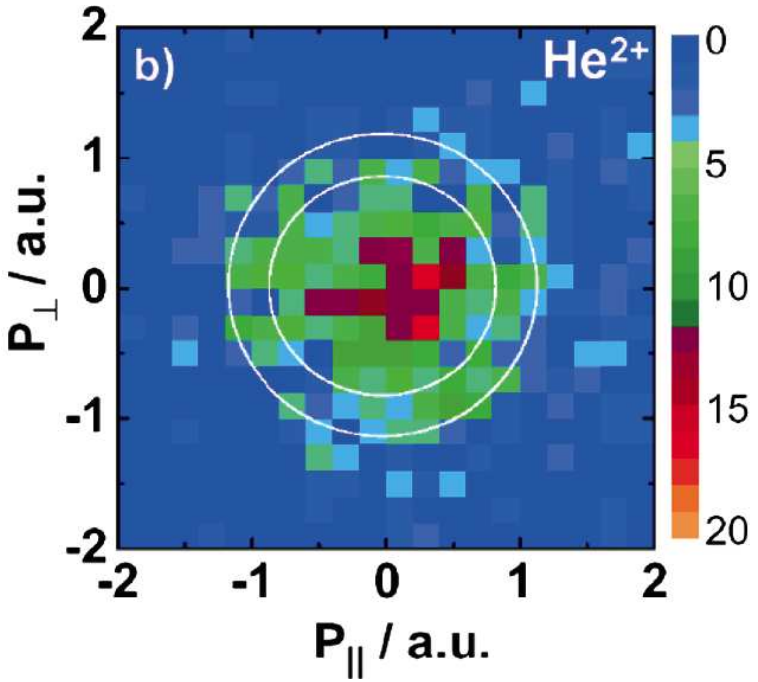
$h\nu + h\nu' + He \Rightarrow He^{2+} + 2e$

44 eV ~ 10^{14} W/cm^2 100 Hz?

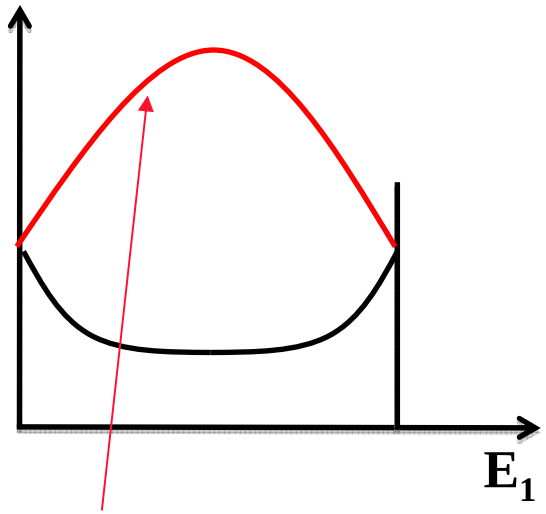


He^{2+} ions, no coincidence

$\vec{p}_1 + \vec{p}_2 + \vec{P}_i = 0$

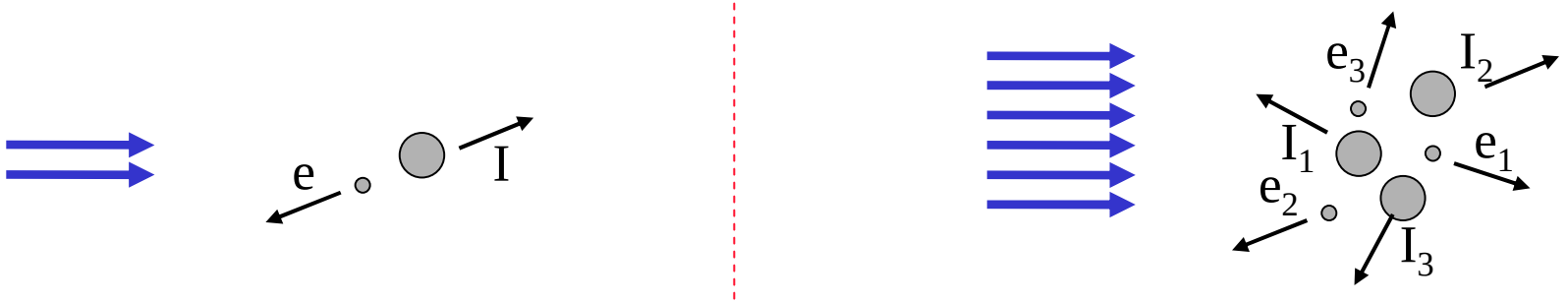


Rudenko et al, PRL 101, 073003 (2008)



Foumouo et al, JPB 41, 051001 (2008)

Condition for coincidences

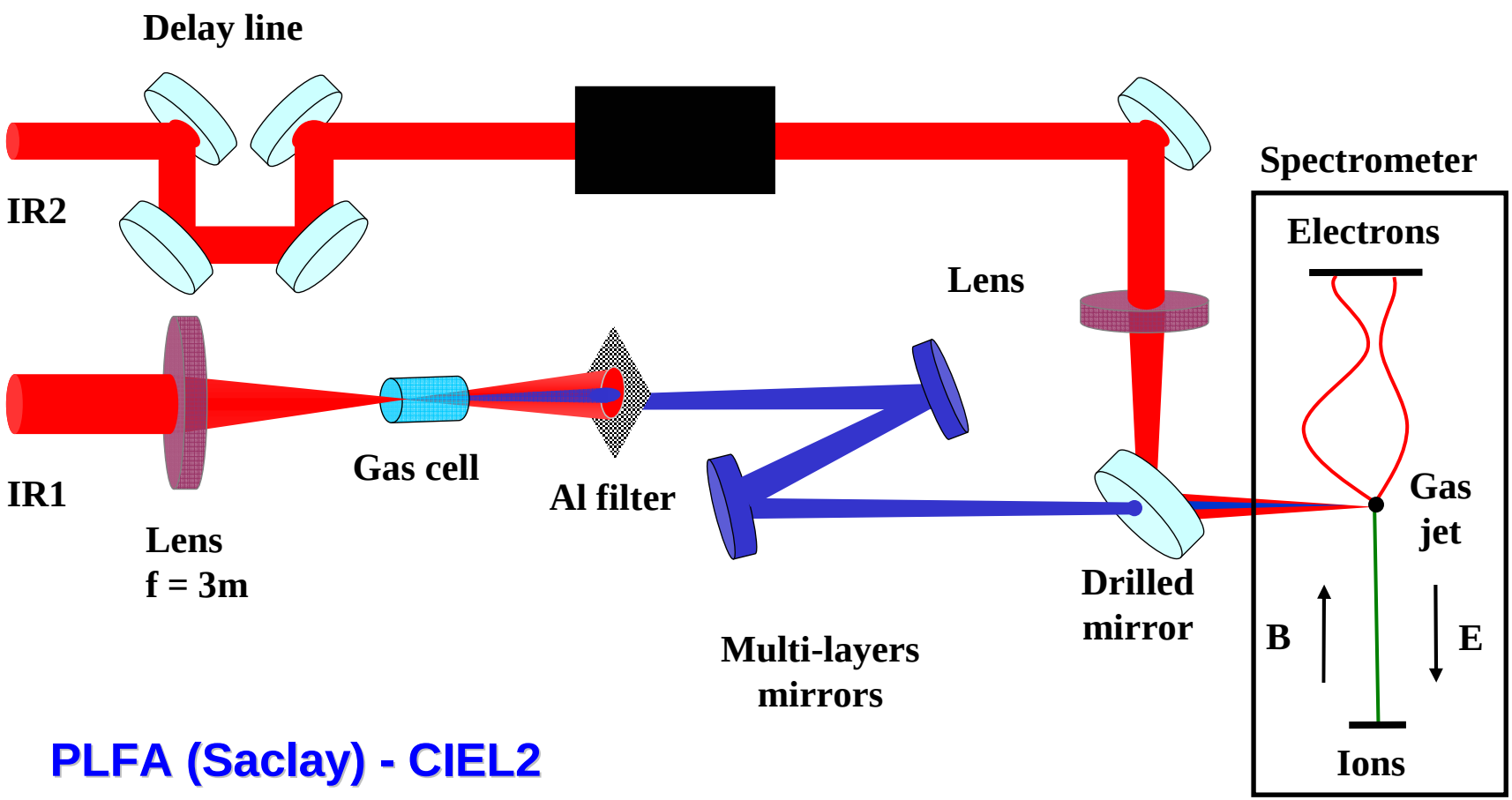


Probability of 1 event for 1 photon pulse ~ 0.1

Consequences:

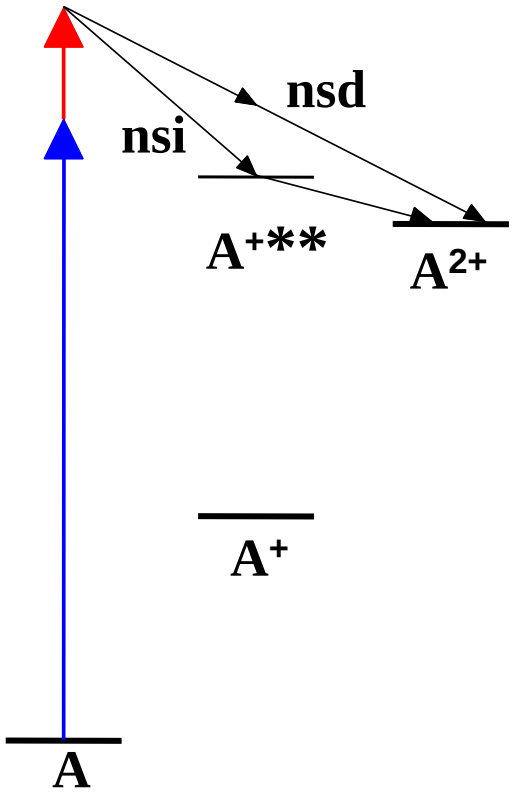
- **with laser sources low density is required in the gas beam**
- **the number of recorded events scales as the r.r. !!!!**

2 colour PDI of xenon –Harmonic source -1 kHz



PLFA (Saclay) - CIEL2

2 colour PDI : non-sequential processes



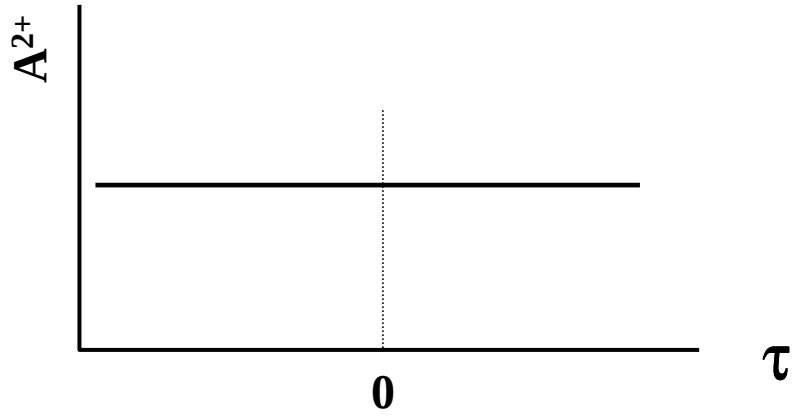
Direct (nsd)

- **coulomb repulsion (e_1 - e_2)**
- **symmetry (↔nb of photons)**

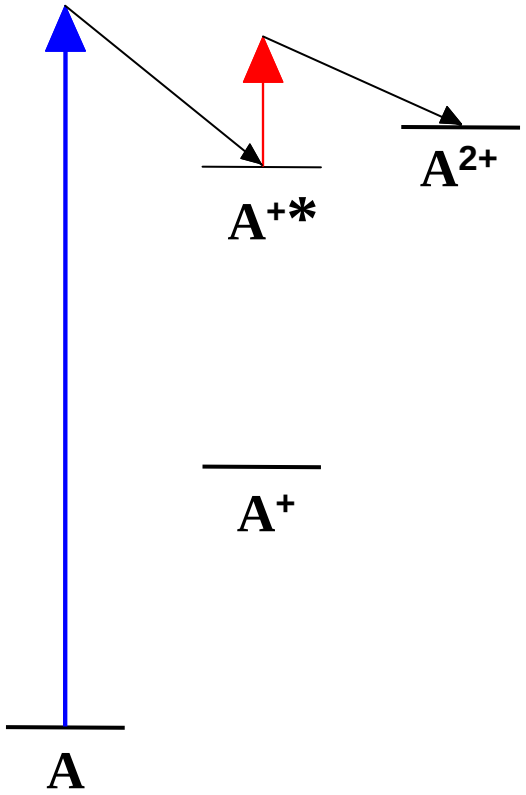
Indirect (nsi)

- **discrete values of E_1 and E_2**
- **no coulomb repulsion (e_1 - e_2)**

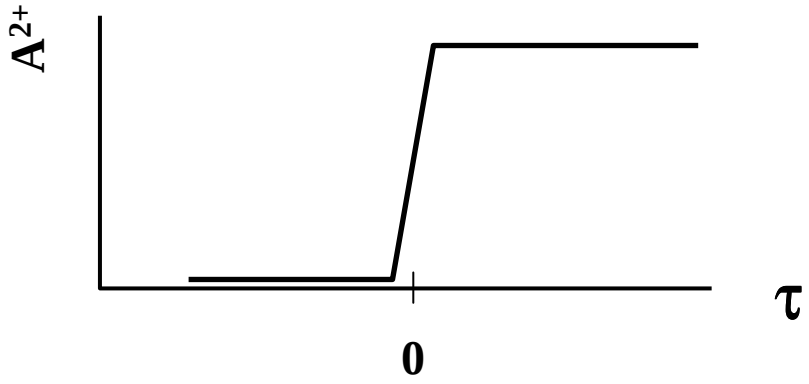
A^{2+} signal constant / τ



2 colour PDI : sequential process

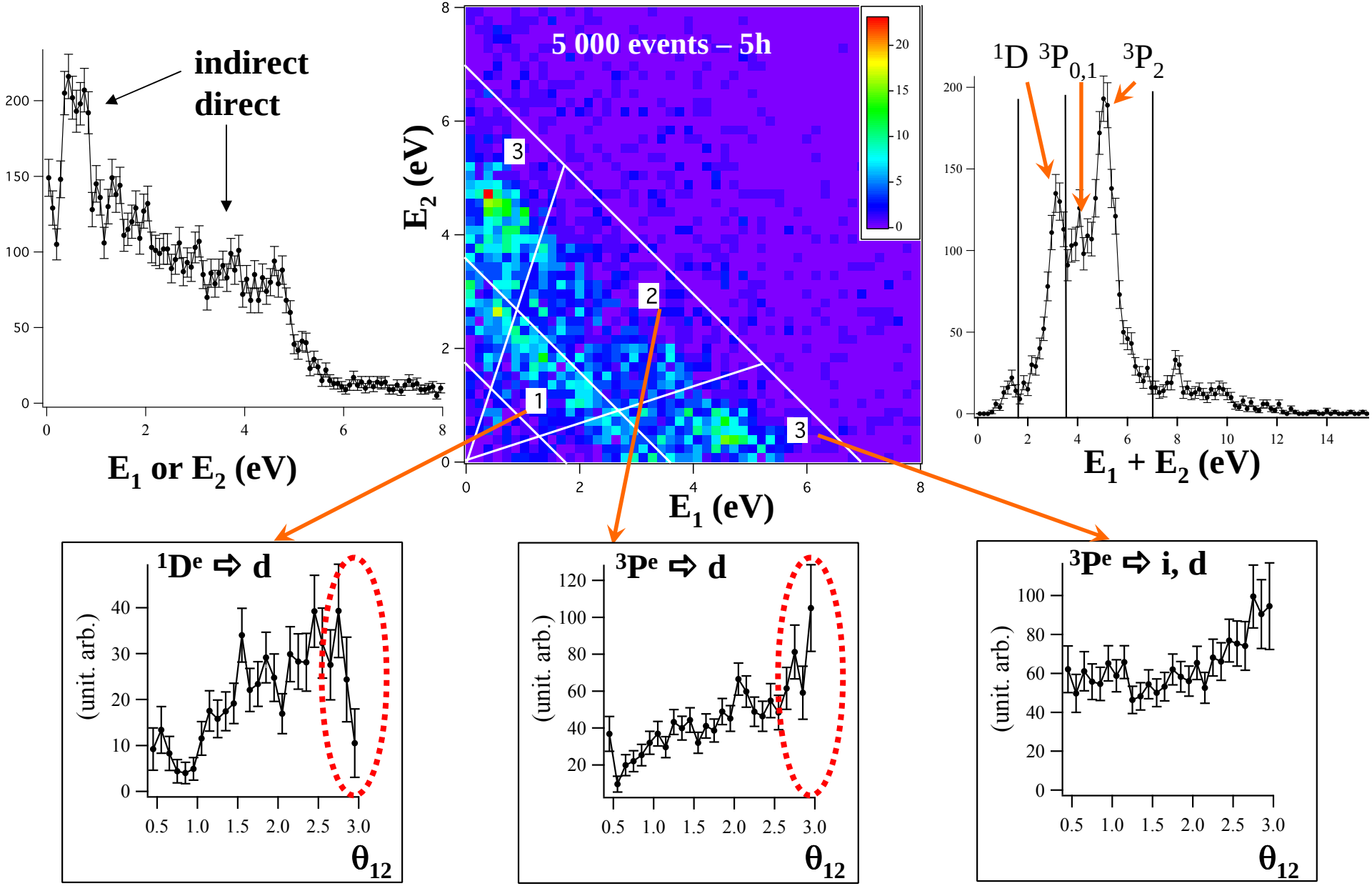


- E_1 and E_2 discrete
- no coulomb repulsion between e_1 and e_2
- step in A^{2+} signal / τ



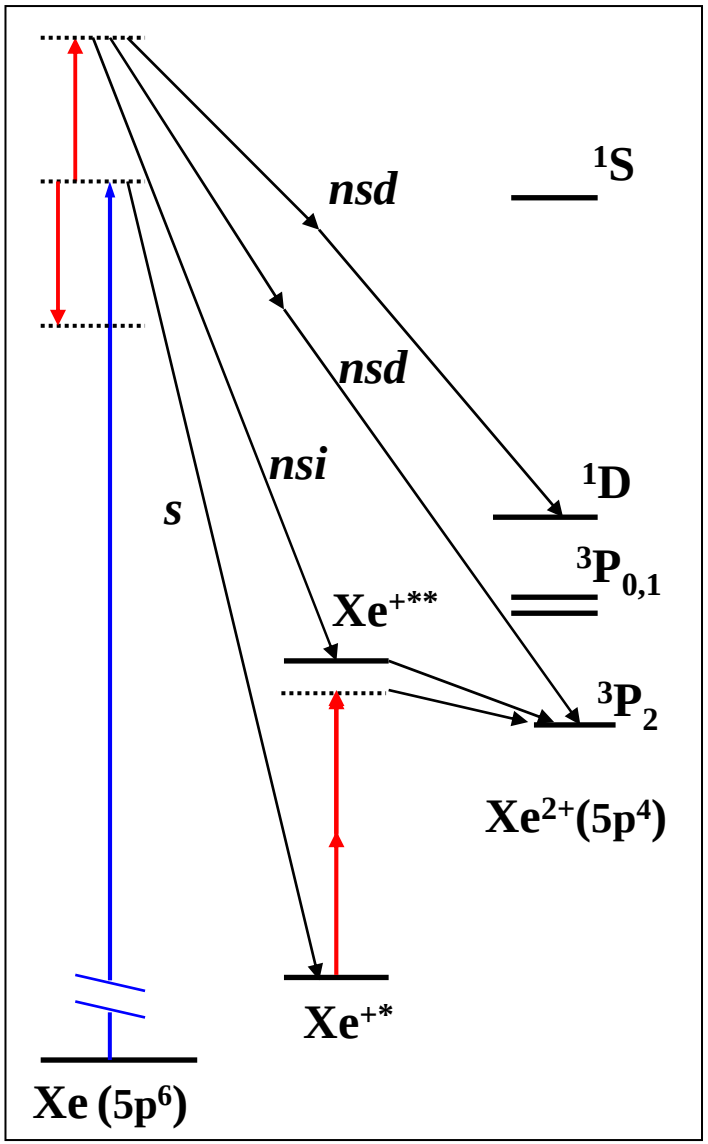
PDI of Xe: 25th harmonic alone

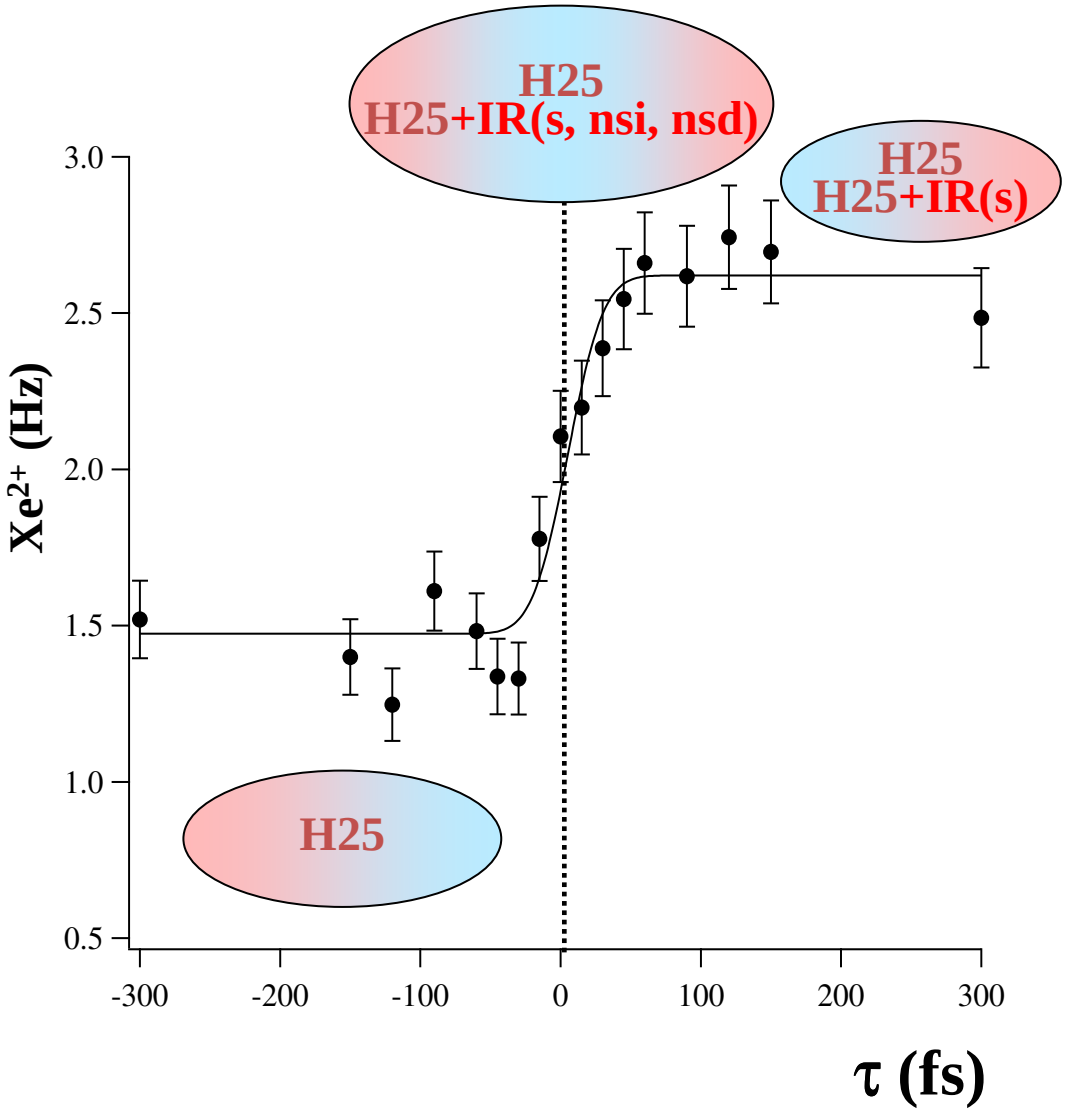
Guyétand et al
J. Phys. B: 41 065601 (2008)



PDI of Xe: 25th harmonic + IR

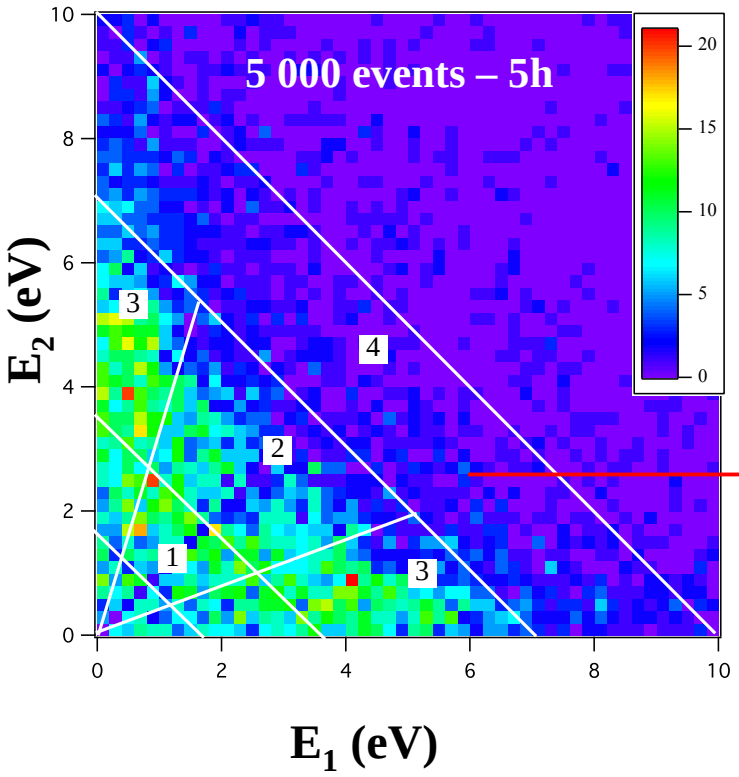
Guyétand et al
J. Phys. B: 41 065601 (2008)

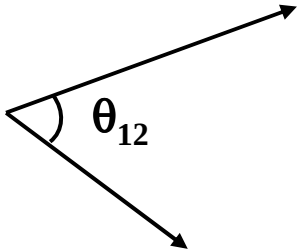


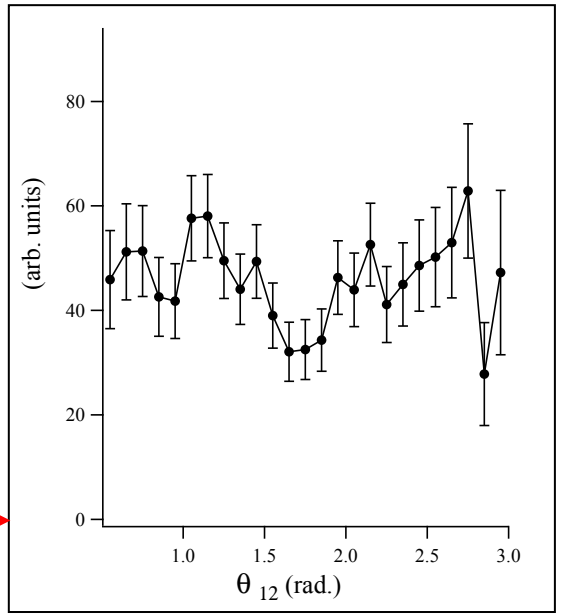


PDI of Xe: 25th harmonic + IR (τ=0)

Guyétand et al
J. Phys. B: 41 065601 (2008)







2 colour PDI (region 4) :

sequential via Xe^{+}*

non sequential indirect via Xe^{+}**

Comparison of XUV sources

	Synchrotron	HHG	FLASH
$\Delta E/E$	10^{-5}	10^{-4}	10^{-3}
ph/s	10^{14}	10^{8}-10^{11}	10^{15}
ph/pulse	10^{7}	10^{6}-10^{10}	10^{14}
energy/pulse	1 nJ	1 μJ	10 - 100 μJ
intensity	10^{5} W/cm^2	10^{12} W/cm^2	10^{14} - 10^{16} W/cm^2
hν	IR - X-Ray (eV - keV)	IR - XUV (eV,200eV)	VUV - XUV 15 - 200 eV
tunability	easy	limited	possible
repetition rate	pulsed MHz	pulsed 1 kHz	pulsed 5x200=1 kHz ?
temporal width	30-50 ps	10 fs	10 - 20 fs

Conclusion : requirements for AEC

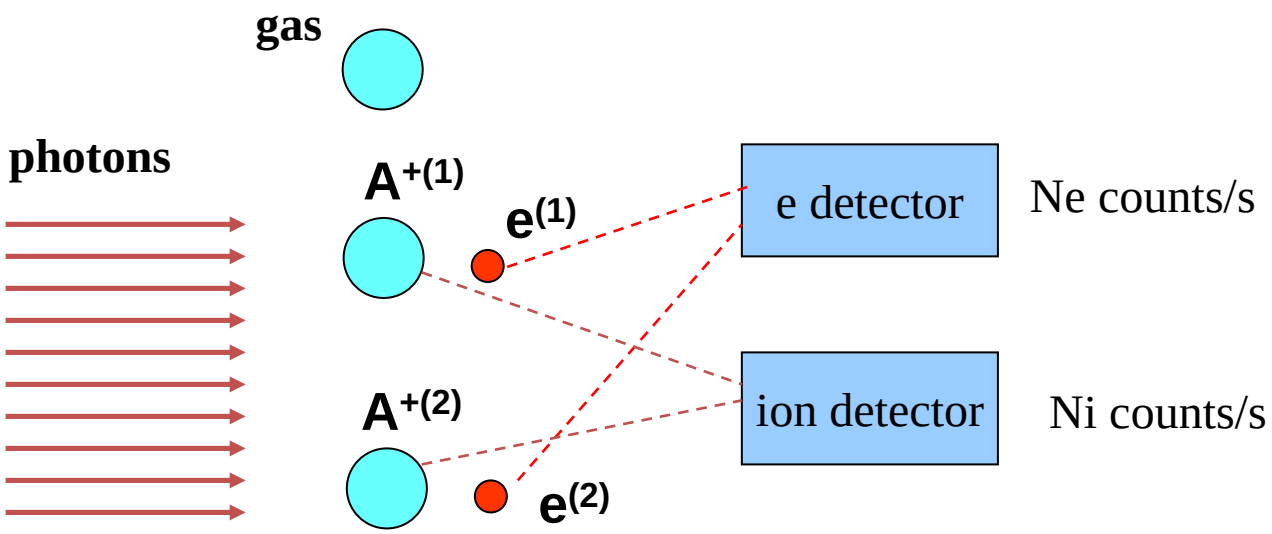
- **intensity ~ threshold for 2 XUV photons**

  ~ 10 μJ / pulse

  ~ 10^{14} W/cm^2

- **repetition rate as high as possible !!!**

true/random ratio with pulsed photon sources



detected events by coincidence system :

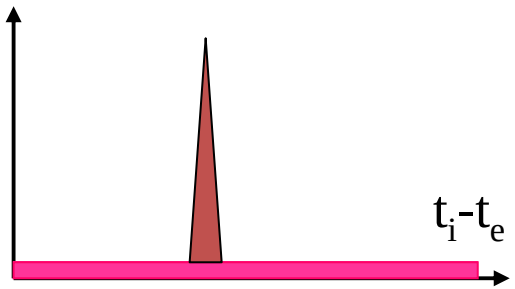
$A^{+(1)}\ e^{(1)}$ T

$A^{+(1)}\ e^{(2)}$ R

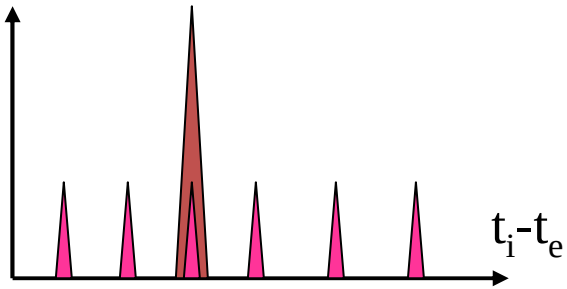
$A^{+(2)}\ e^{(1)}$ R

$A^{+(2)}\ e^{(2)}$ T

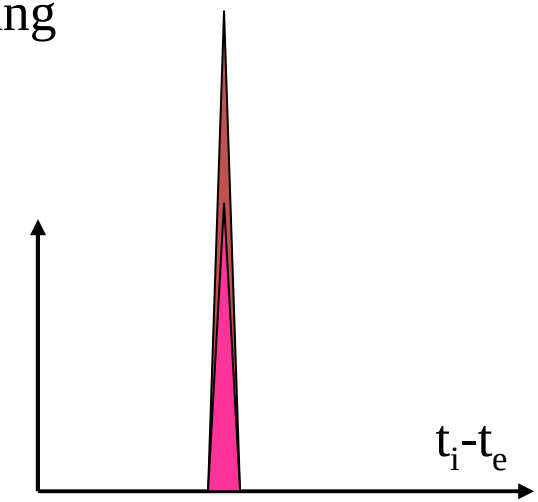
coincidence time spectra for various photon sources, keeping the same N_e , N_i , time window and acquisition time



cw source



high repetition rate



low repetition rate