Angular Correlation between Photo- and Auger Electrons following Photoionization of Neon

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Core Photoionization of Neon

photoelectron

$h\nu + Ne(1s^2 2s^2 2p^6) \rightarrow Ne(1s 2s^2 2p^6)^+ + e_\nu(\varepsilon p)$

$Ne(1s^2 2s^2 2p^4 np)^+ + e_A$
(Recapture)

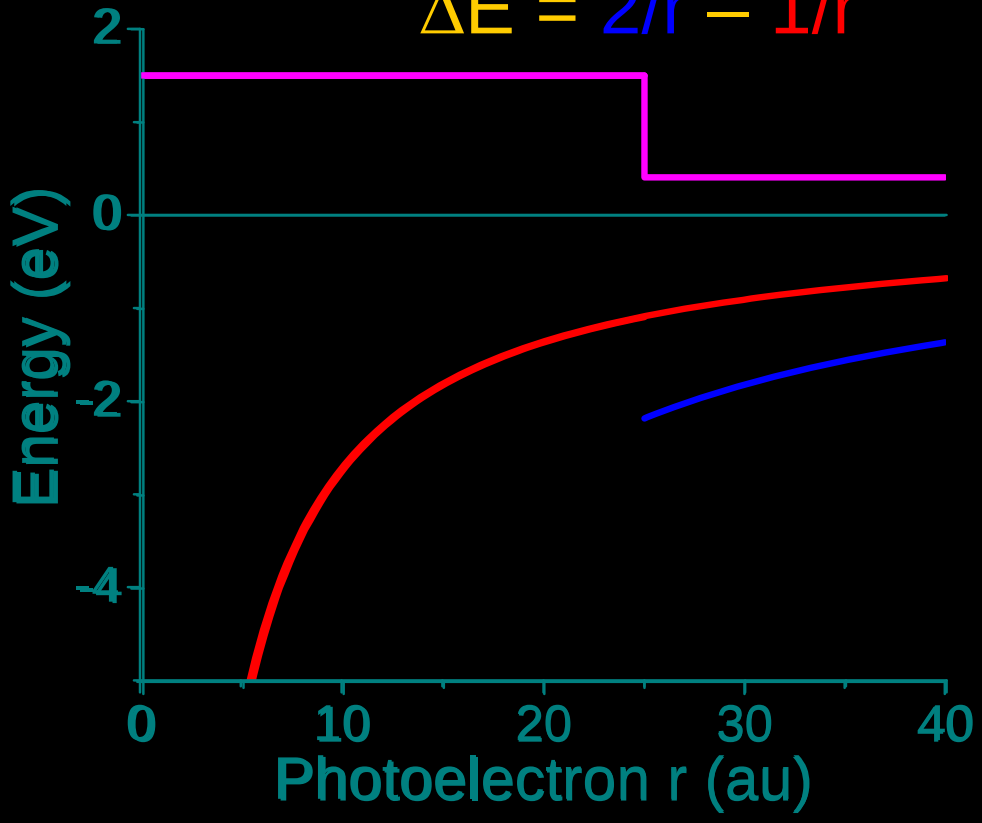
$Ne(1s^2 2s^2 2p^4)^{++} + e_R$
(Re-Emission)

$Ne(1s^2 2s^2 2p^4)^{++} + e_A + e_\nu$

~800 ev ~1 eV

$Ne(1s^2 2s^2 2p^5)^+ + h\nu_2$
(radiative emission ~3%)

$\Delta E = 2/r - 1/r$



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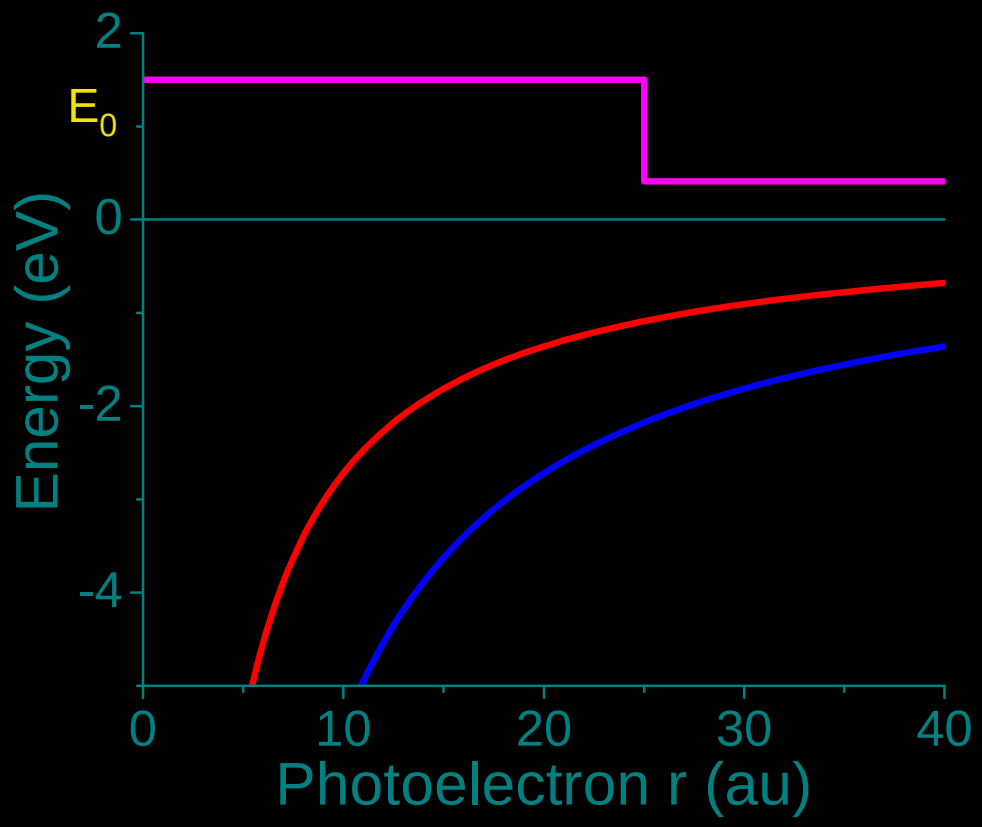
A little bit o' math….(within the sudden approximation)

$\Delta E = 2/r - 1/r = 1/r$

$r = 1 / \Delta E$



$$\frac{v^2}{2} - \frac{1}{r} = E_0 \Rightarrow v = \sqrt{\frac{2}{r} + 2E_0}$$

$$t = \int_0^{r_0} dt = \int_0^{r_0} \frac{dr}{v} = \int_0^{r_0} \frac{dr}{\sqrt{\frac{2}{r} + 2E_0}}$$

Ideas:

- Know E_0, from $h\nu$
- Know r, from measuring ΔE
- Infer Time!!
- Decay → Escape Probability

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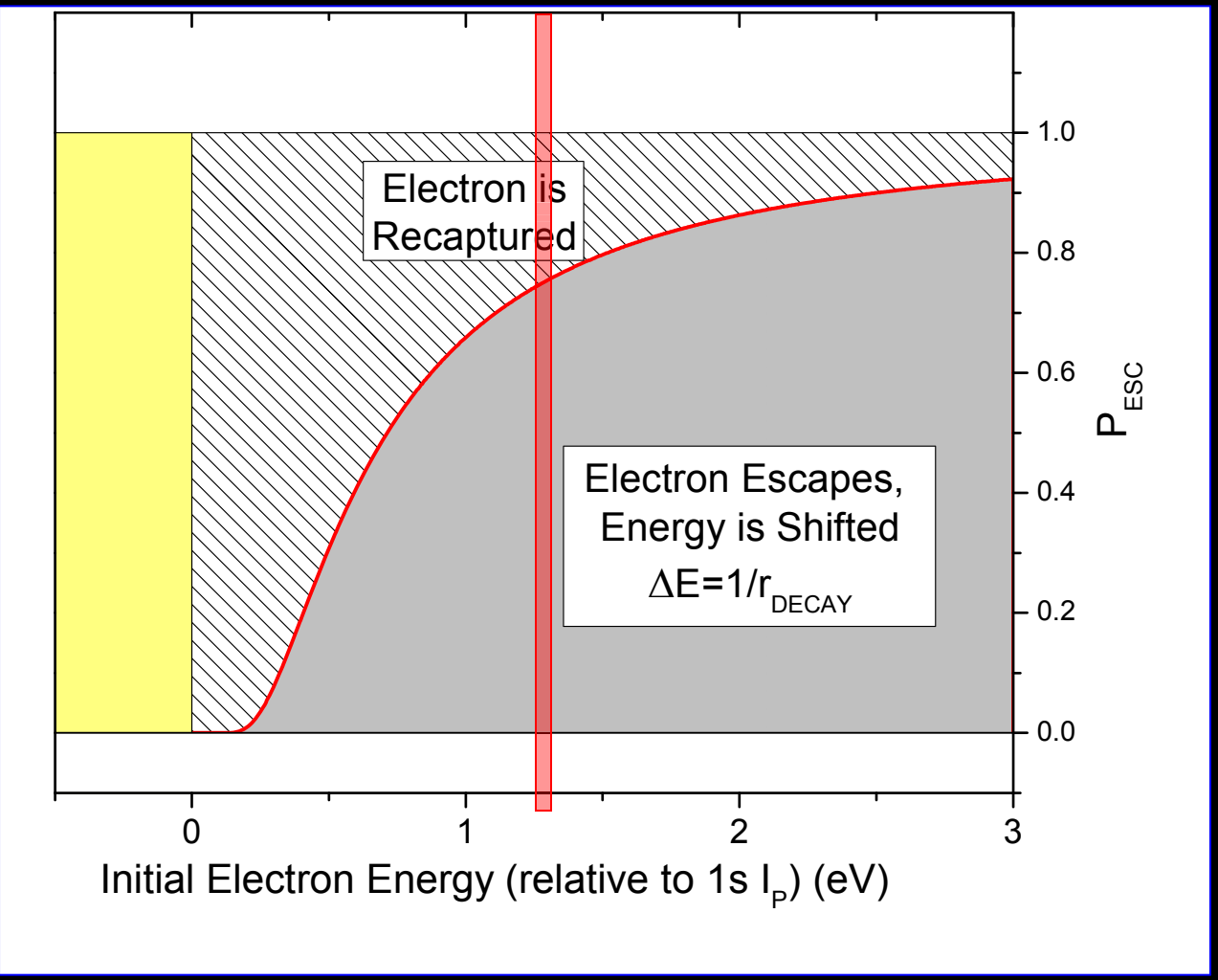
Escape Probability



Photon Energy	Approx Probability	Data (Gb)
0.299	10%	7.34
0.426	20%	1.01
1.360	70%	9.55
1.410	75%	4.38
2.429	90%	3.41
2.607	90%	9.11
3.407	>90%	4.09

Questions:
How can we get enough >870 eV photons, with energy resolution ~100meV?

How can we measure this process?

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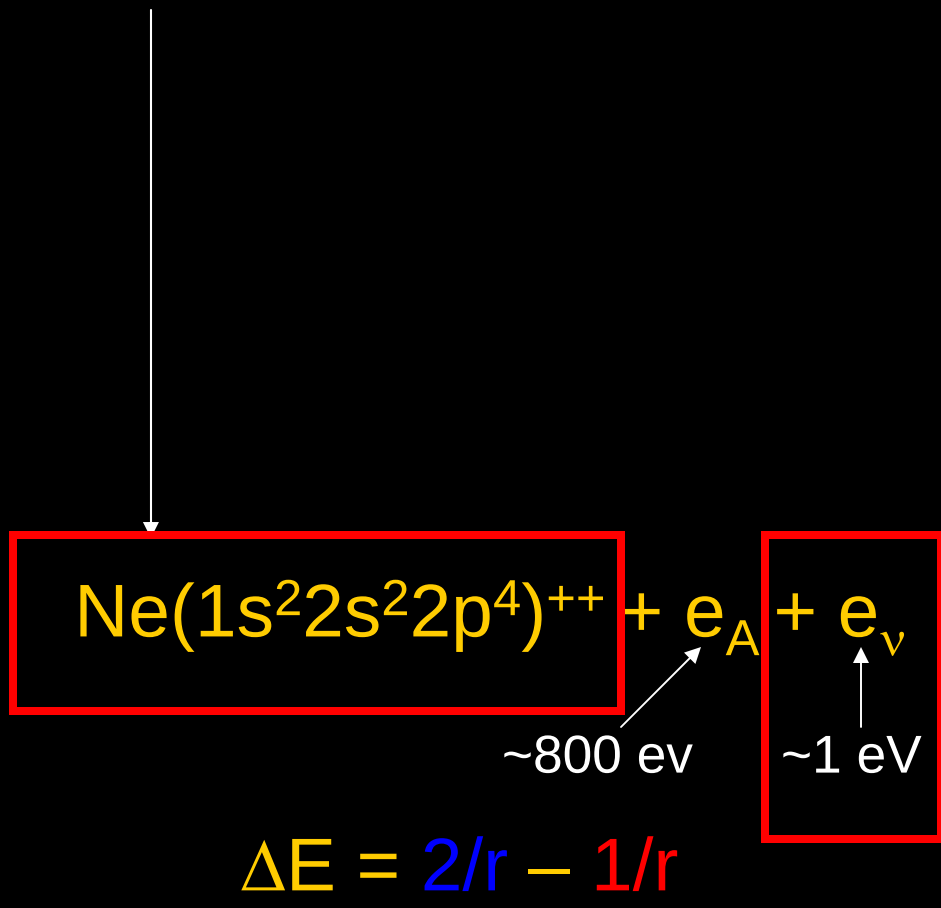
What will we measure?

$h\nu + Ne(1s^2 2s^2 2p^6) \rightarrow Ne(1s 2s^2 2p^6)^+ + e_\nu(\varepsilon p)$

photoelectron

Conservation of momentum gives us Auger momentum



$\Delta E = 2/r - 1/r$

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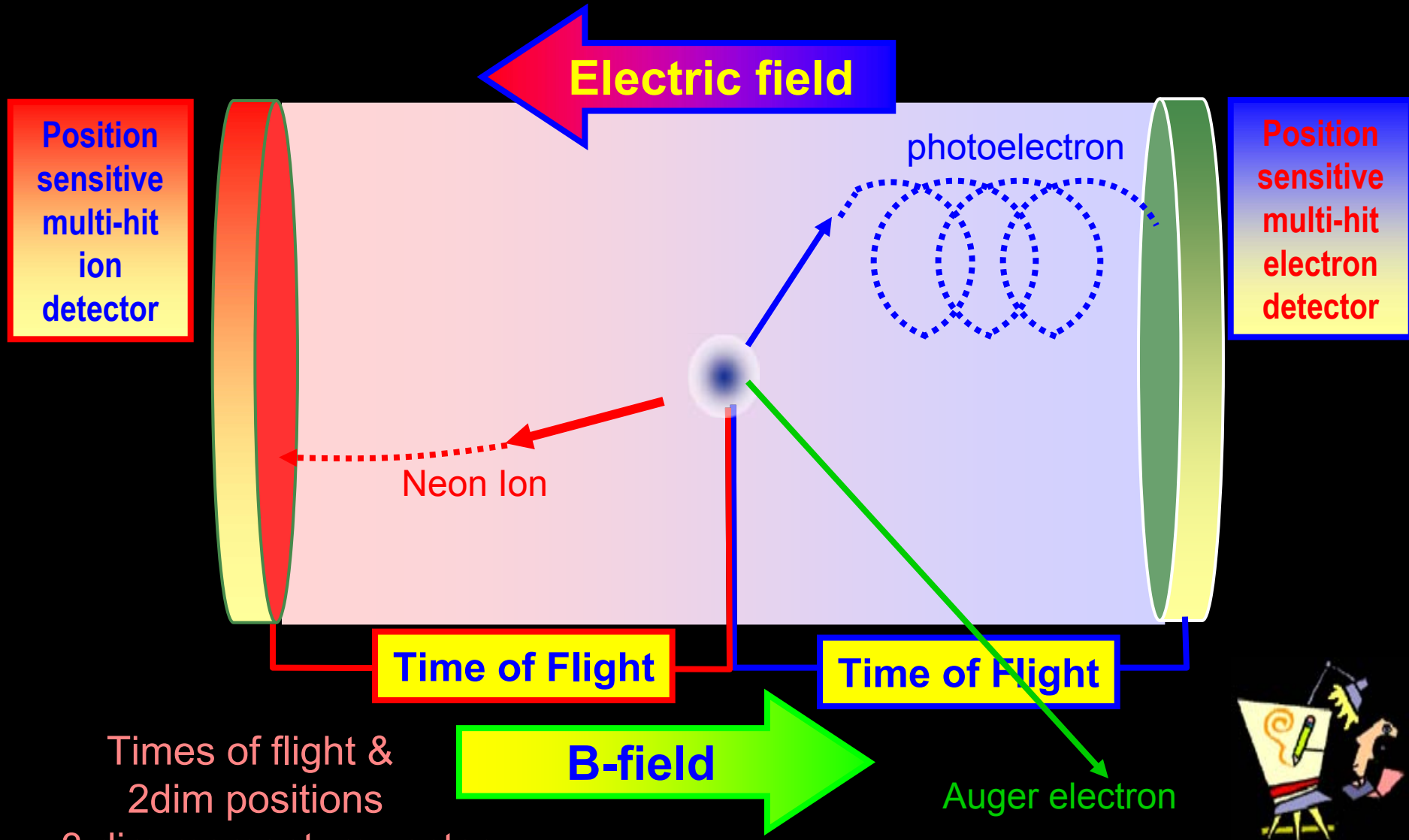
Momentum Imaging



Times of flight &
2dim positions
$\Rightarrow$ 3 dim momentum vector

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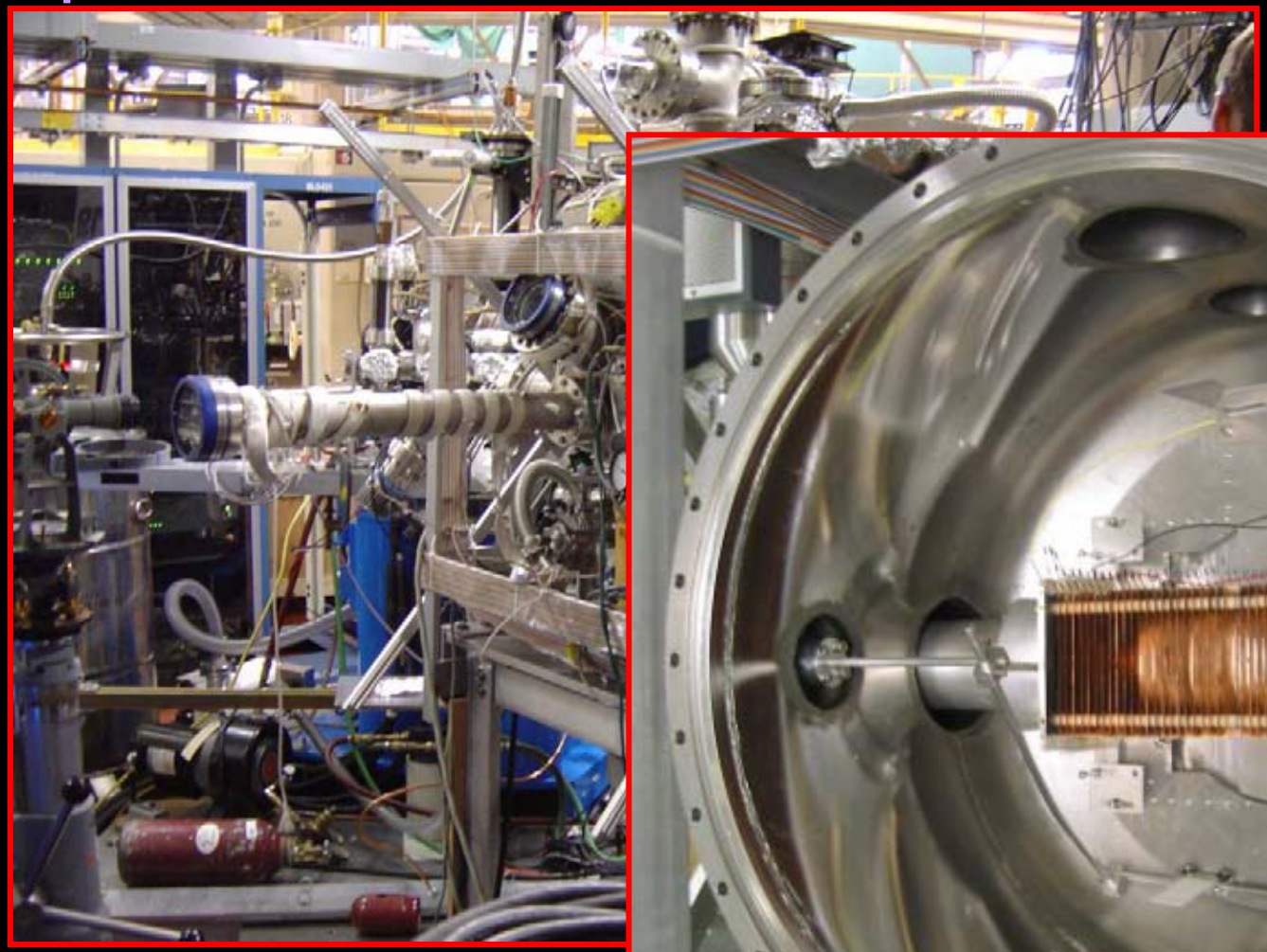
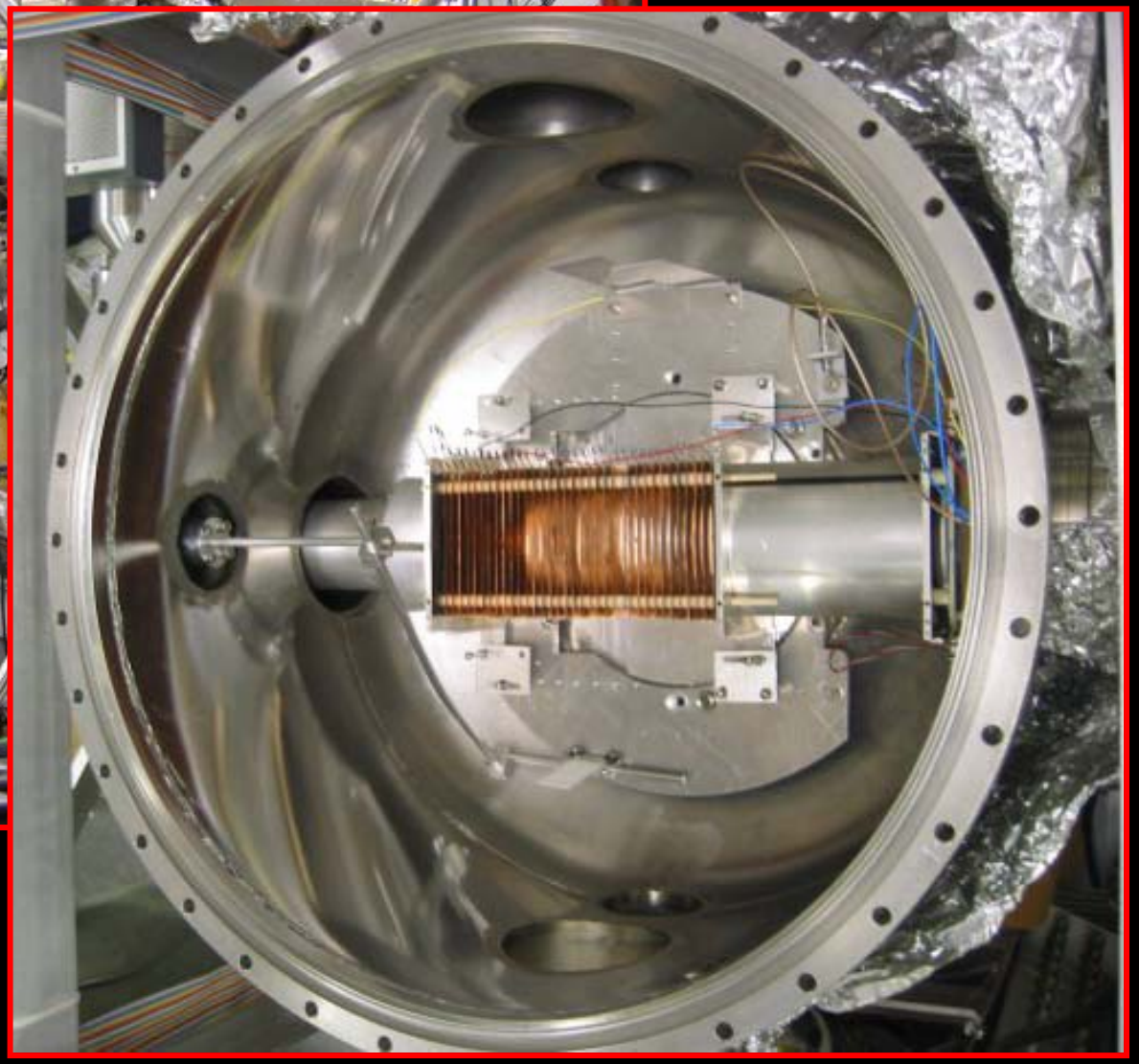
Pipes, Wires and a Chamber





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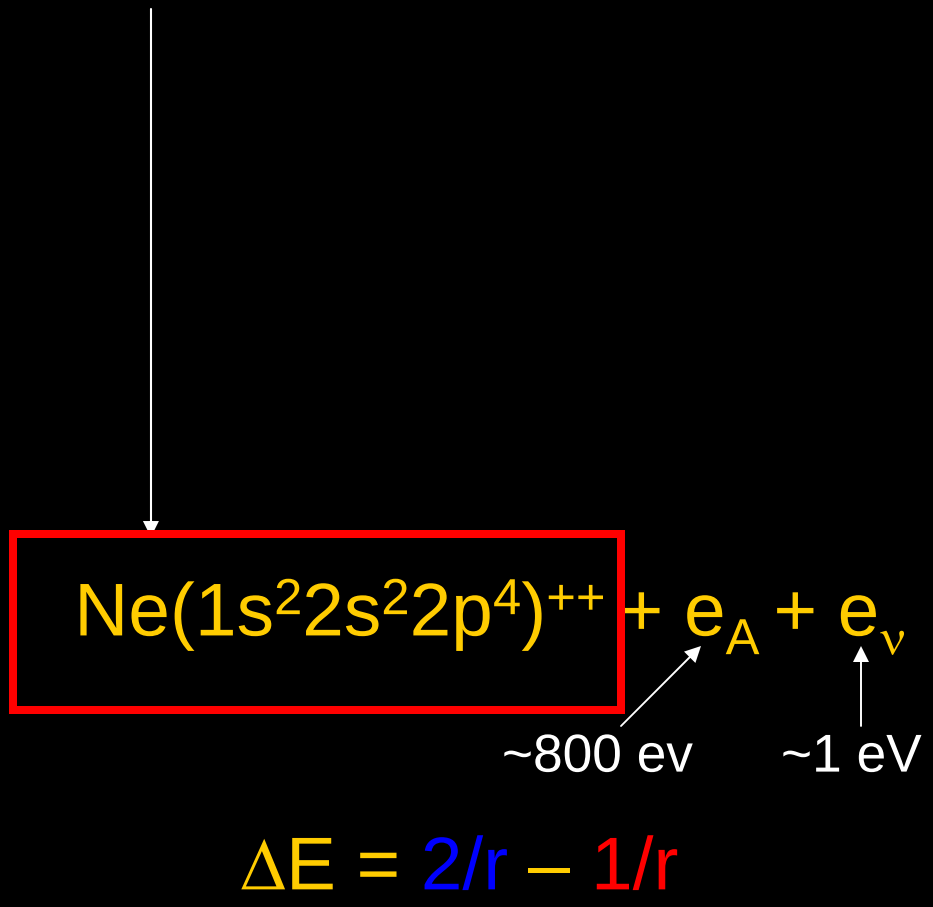
What will we measure?

photoelectron

$$h\nu + Ne(1s^2 2s^2 2p^6) \rightarrow Ne(1s 2s^2 2p^6)^+ + e_\nu(\varepsilon p)$$

First, the ions



$$\Delta E = 2/r - 1/r$$

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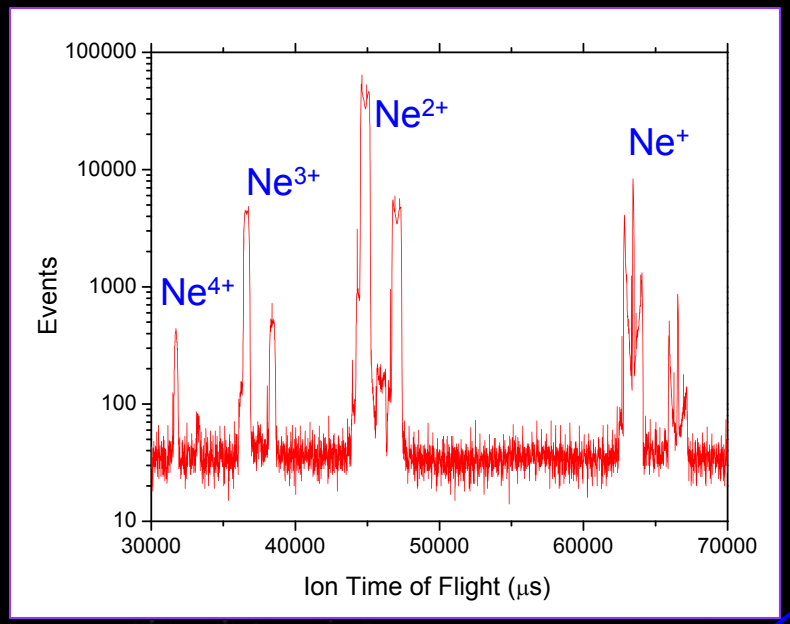
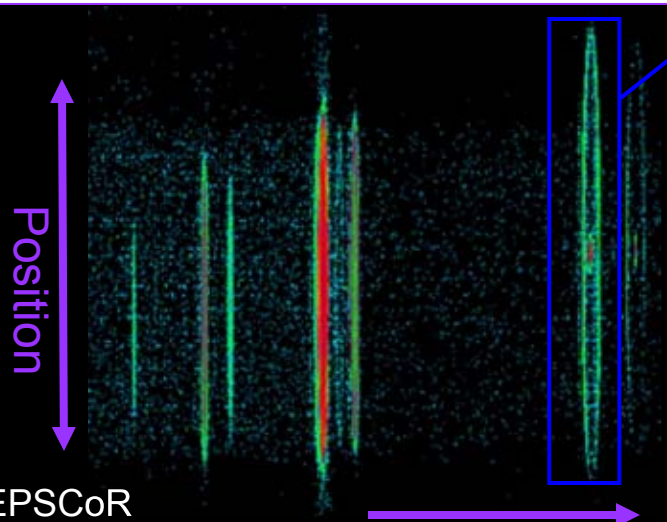
Recoil Ions: TOF, Position

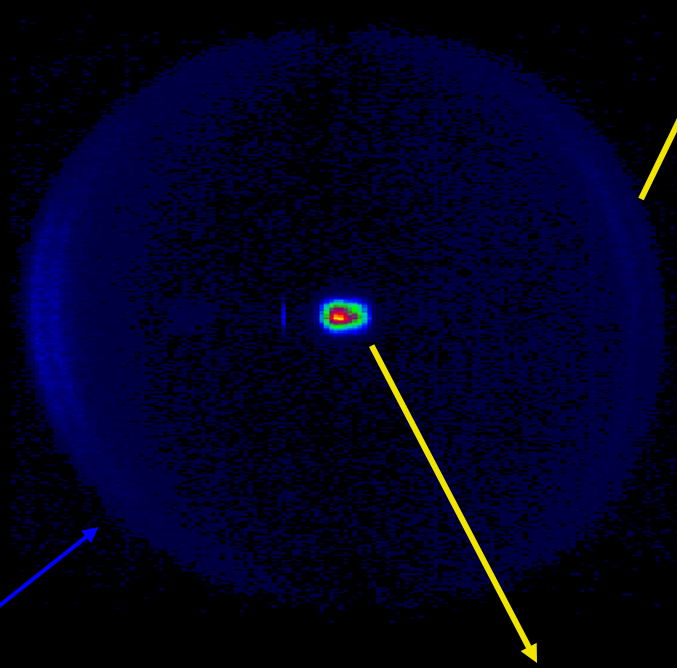




$P_Z = Eq\Delta t$

$P_X = mx/t \sim x$

$P_Y = my/t \sim y$



$Ne(1s^22s^22p^5)^+ + e_\nu(\varepsilon p)$

$\varepsilon > 800eV$

$P_e \sim 8$ au

Big Kick!

$Ne(1s2s^22p^6)^+ + e_\nu(\varepsilon p)$

$Ne(1s^22s^22p^5)^+ + h\nu_2$

(radiative emission)

$\varepsilon = 1.4eV$ $(p_e = 0.3au)$

$h\nu_2/c = 0.2$ au

Little Kicks!

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What will we measure?

photoelectron

$$h\nu + Ne(1s^2 2s^2 2p^6) \rightarrow Ne(1s 2s^2 2p^6)^+ + e_\nu(\varepsilon p)$$

Now, the photoelectrons

$$Ne(1s^2 2s^2 2p^4)^{++} + e_A + e_\nu$$

~800 ev ~1 eV

$$\Delta E = 2/r - 1/r$$

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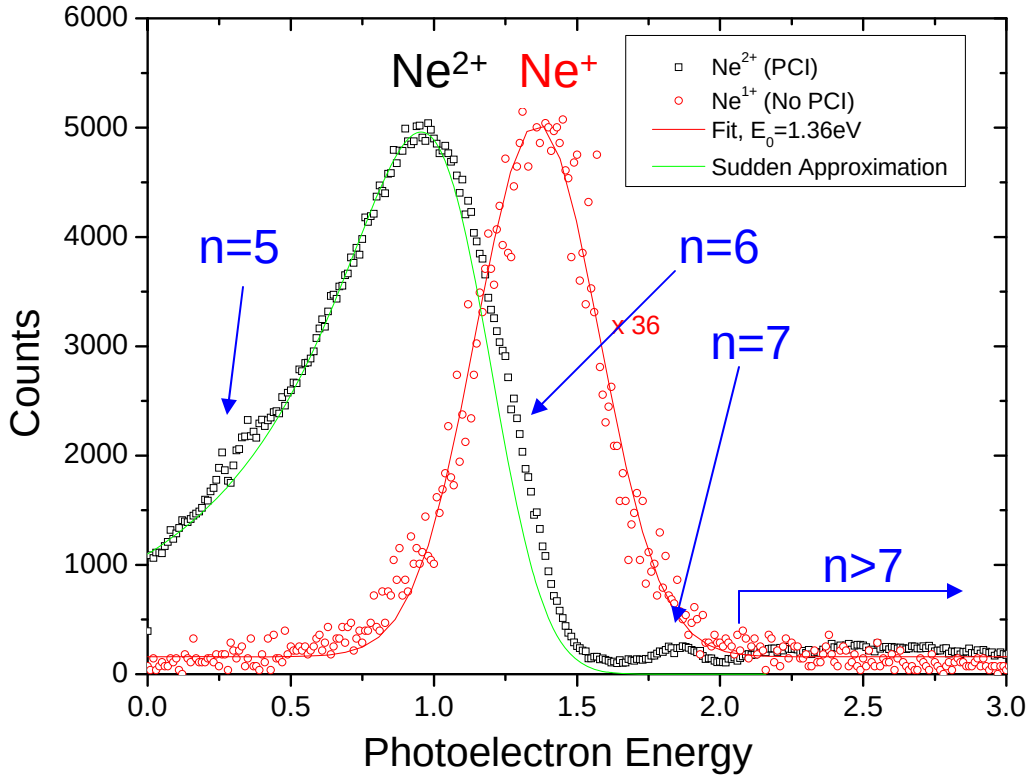
Photoelectron Energy (integrated over angle)



Ne+ $1s^2 2s^2 2p^4 np(^1D,^1S)$

Radiative Channel gives Accurate photon Energy

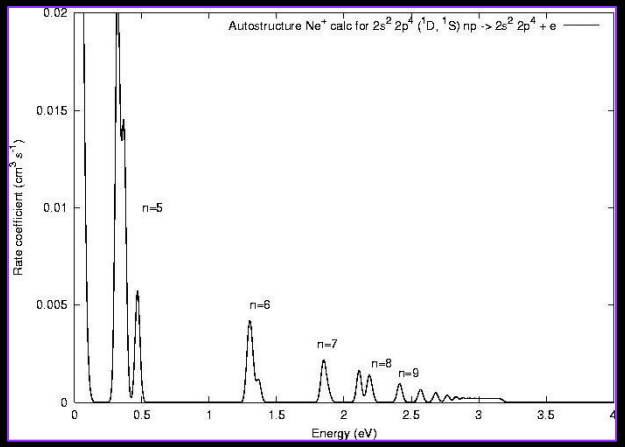
Γ=270meV dE_{exp} = 140meV

Auger Channel Shows Energy Shift and Recapture (no width inc!)

Recapture/Re-emission lines

Autostructure Calculation

Stuart Loch (Auburn)



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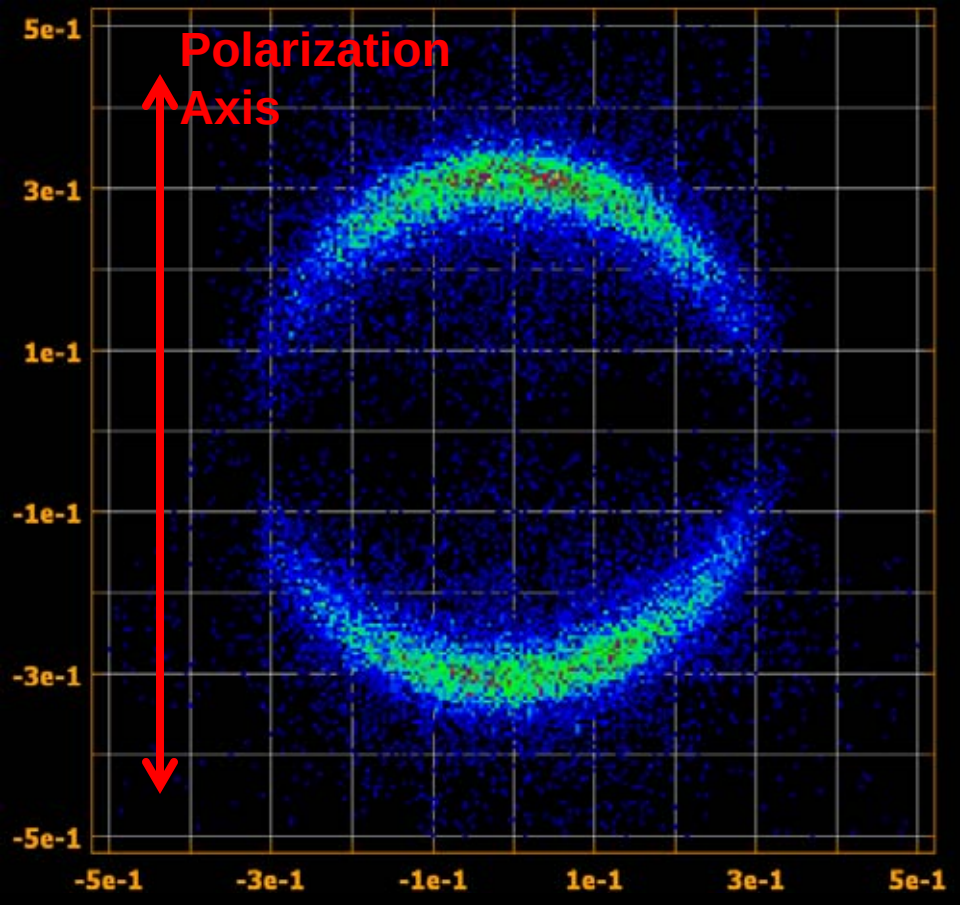
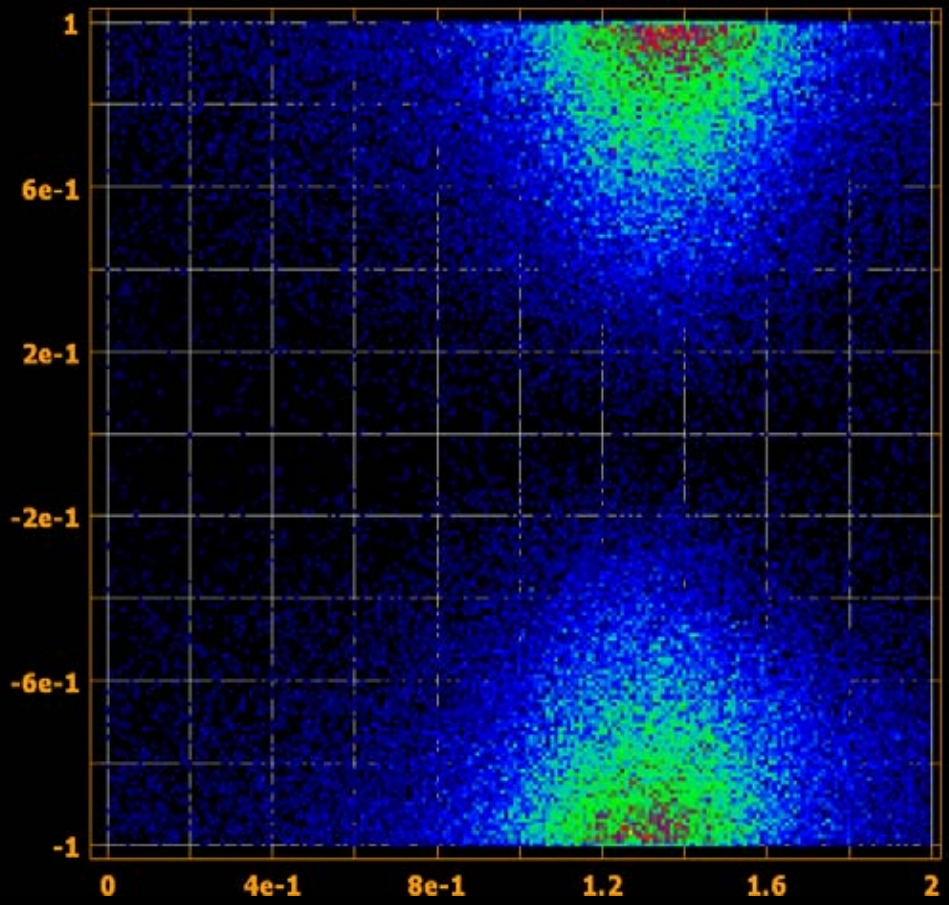
Photoelectron Momentum, Ne^+ (Radiative Decay)

Photoelectron in Momentum Space (slice)



Cos(θ) (relative to polariztion) vs. Electron Energy (eV)



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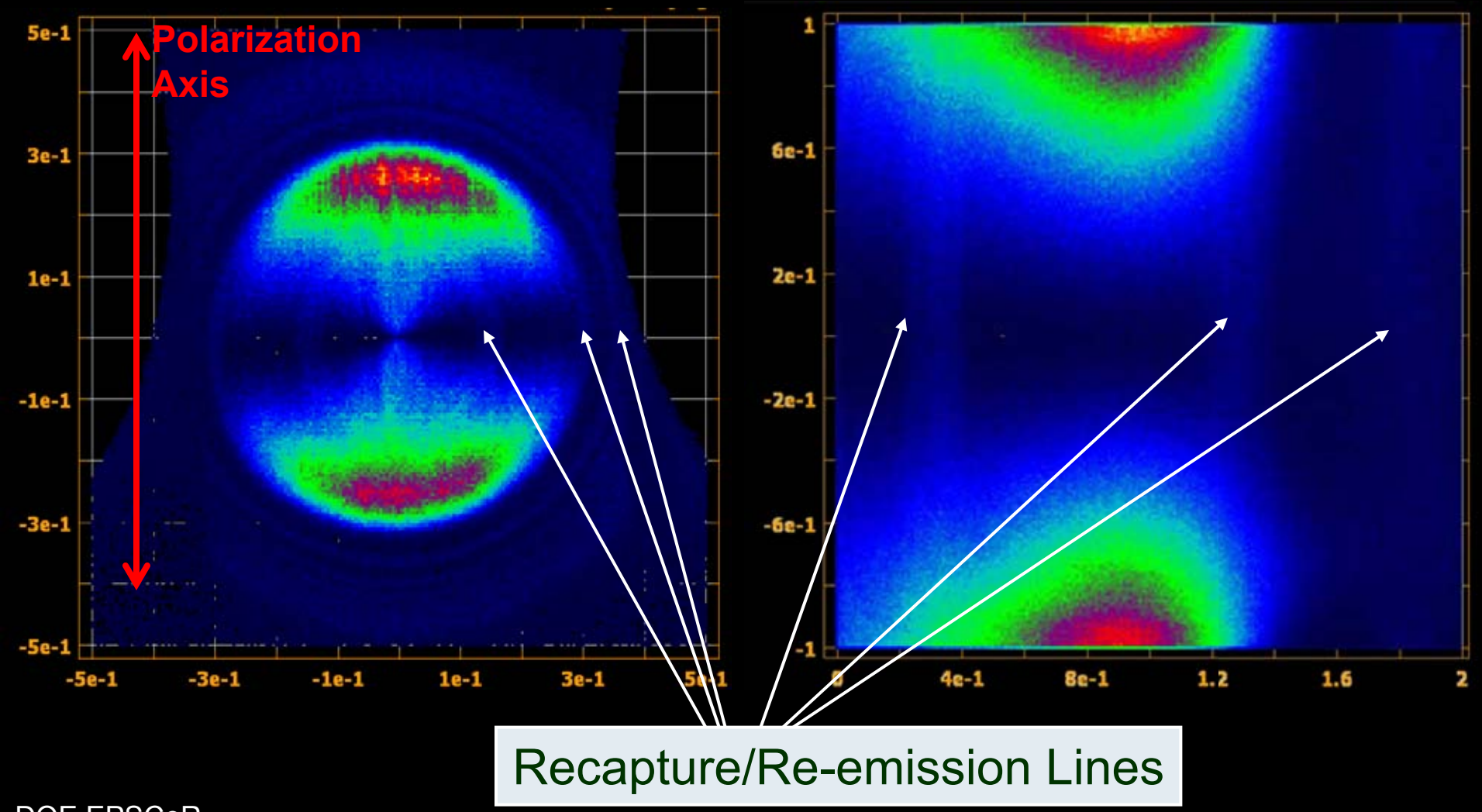
Photoelectron Momentum, Ne^{2+} (Auger Decay)

Photoelectron in Momentum Space (slice)

Cos(θ) (relative to polariztion) vs. Electron Energy (eV)



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What will we measure?

photoelectron

$$h\nu + Ne(1s^2 2s^2 2p^6) \rightarrow Ne(1s 2s^2 2p^6)^+ + e_\nu(\varepsilon p)$$

Now, the Auger electrons (inferred)

$$Ne(1s^2 2s^2 2p^4)^{++} + e_A + e_\nu$$

~800 ev ~1 eV

$$\Delta E = 2/r - 1/r$$

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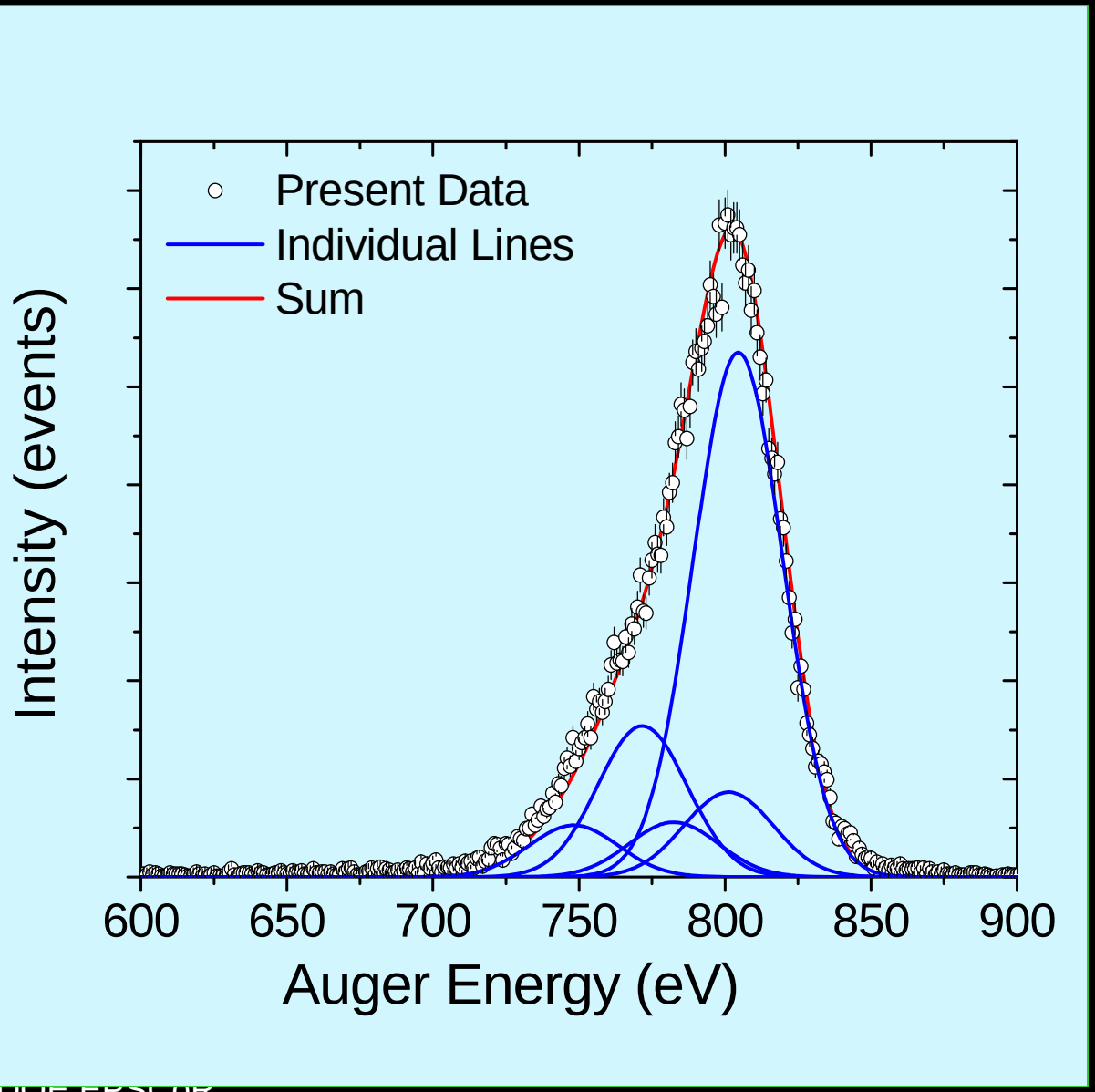
Auger Electrons (inferred from photoelectron + recoil)



Auger Channel has 5 lines:

Final State	Energy (eV)	Fraction
206 ^{1}S	748.4	6%
215 ^{1}P	771.9	17%
215 ^{3}P	782.2	6%
224 ^{1}S	800.7	10%
224 ^{1}D	804.5	61%

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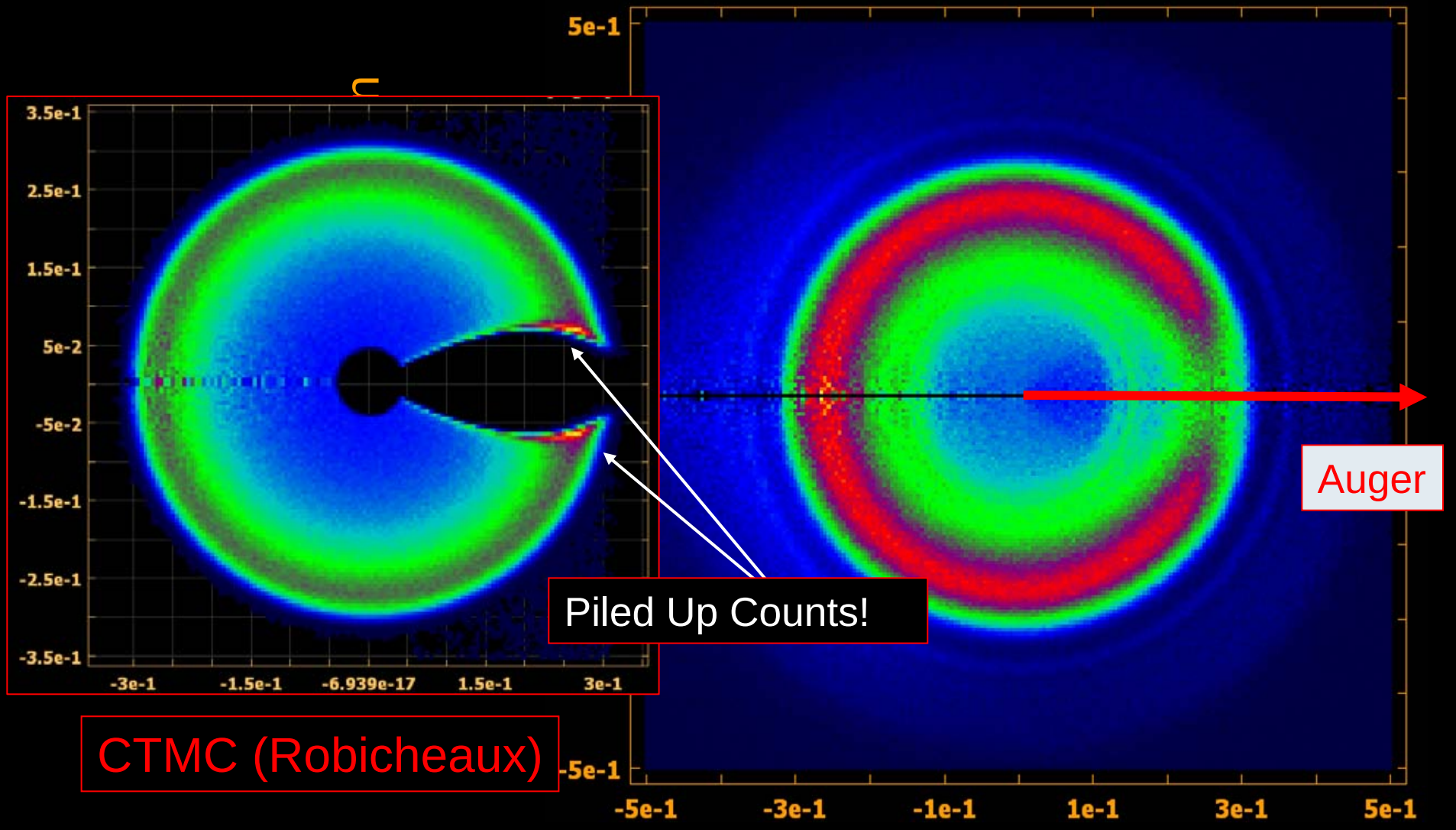
Photoelectron relative to Auger (define a plane)



Parallel Photoelectron Momentum $P_{//}$

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Other Work:

- Fixed in Space Molecules
- Isomerization of HCCH/C_2H_2
- Core Hole Localization in N_2
- Fundamental 4-body Quantum Dynamics in H_2

•MS. Schöffler et al., Science, **320**, (2008) 920-923
•D. Akoury et al., Science, **318**, (2007) 949-952
•F. Martin et al., Science, **320**, (2007) 629-633
•K. Kreidi et al., PRL, **100**, (2008), 133005

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Many Many More….

Special Thanks:
-Roentdek
-Chronologic

Team Support:
US:
Dept. of Energy, Basic Energy Sciences, AMOS Program
Dept. of Energy, DOE EPSCoR Laboratory Partnership Award

Germany:
DFG
BMBF
A v.Humboldt Stiftung
Roentdek GmbH

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