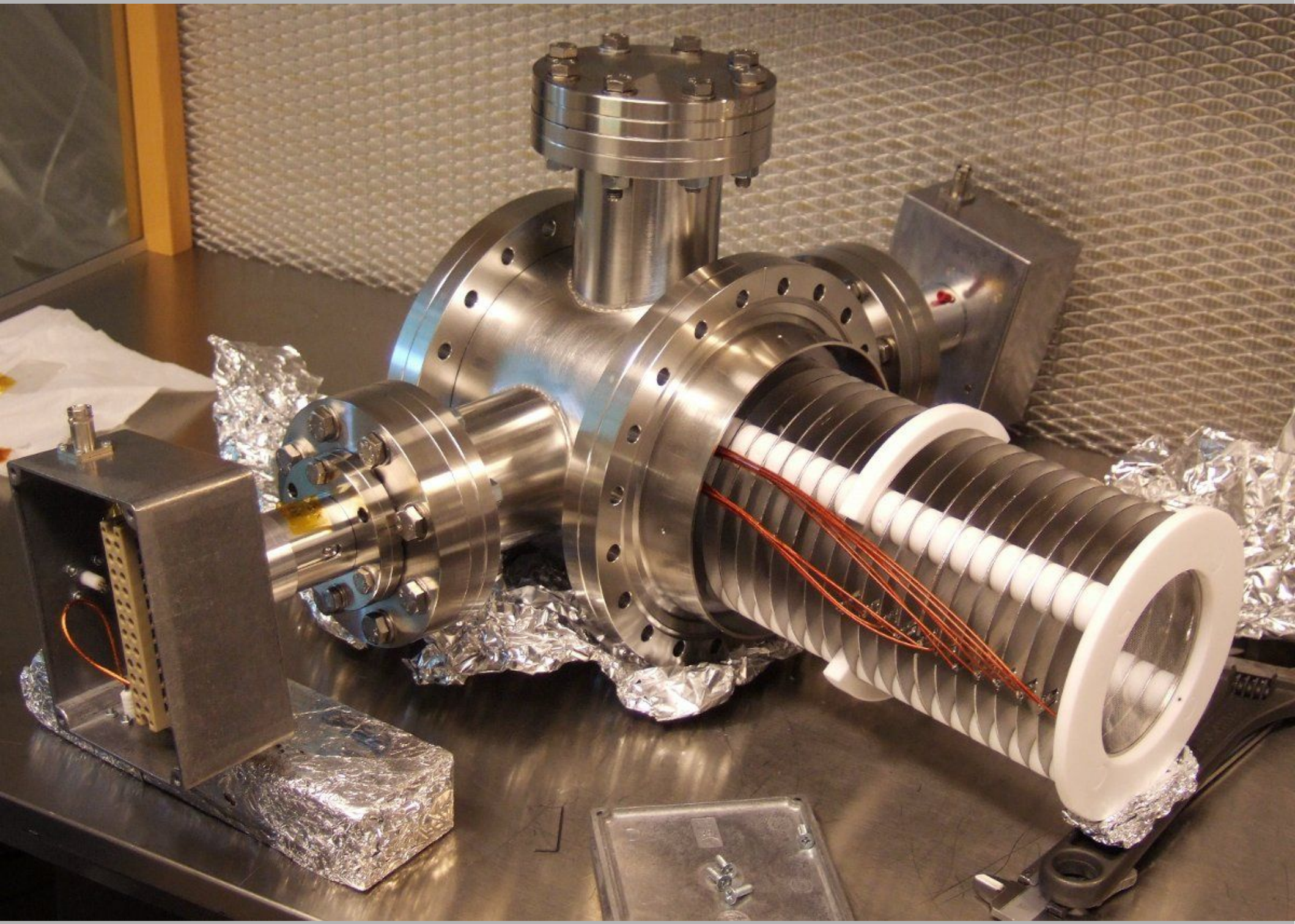
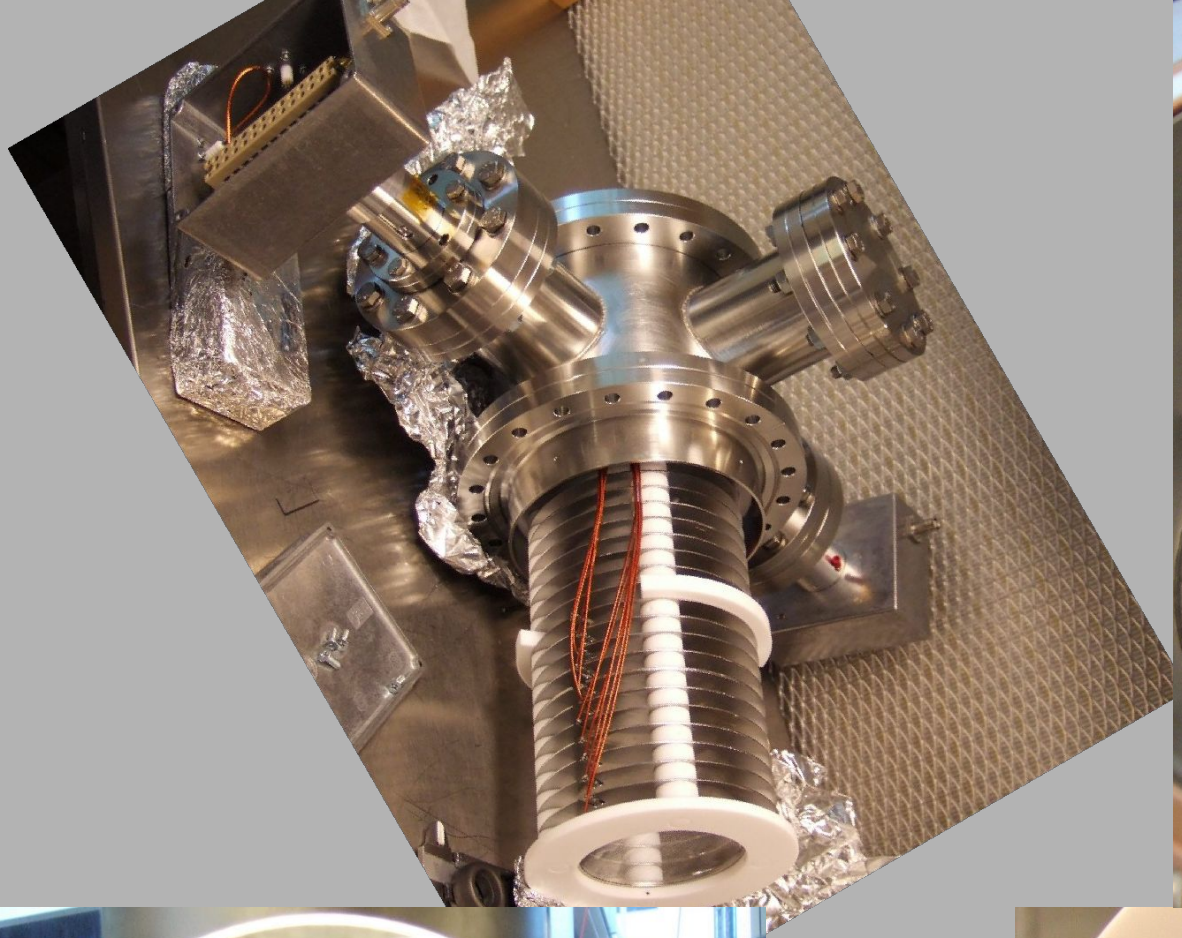
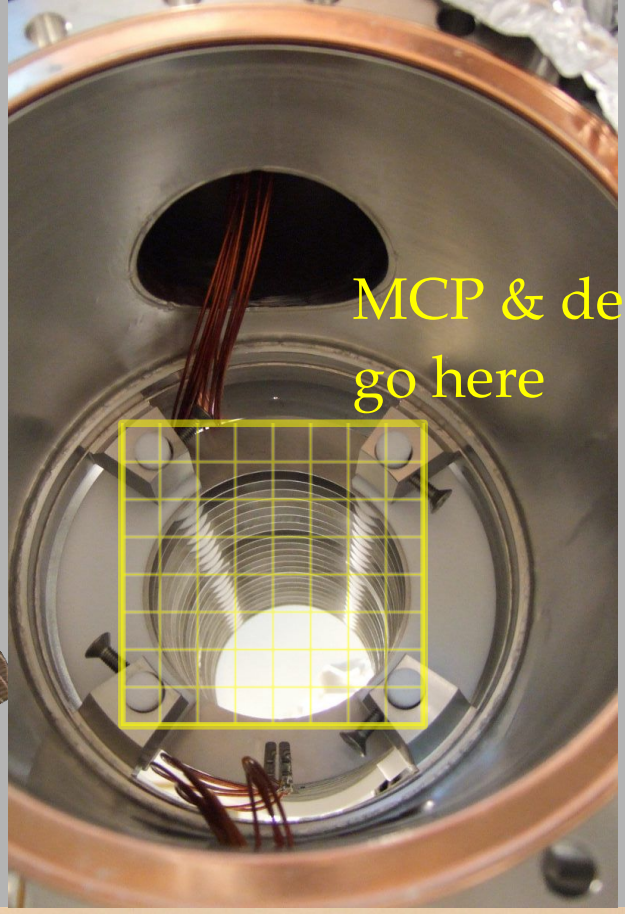
3D ion & electron spectrometer

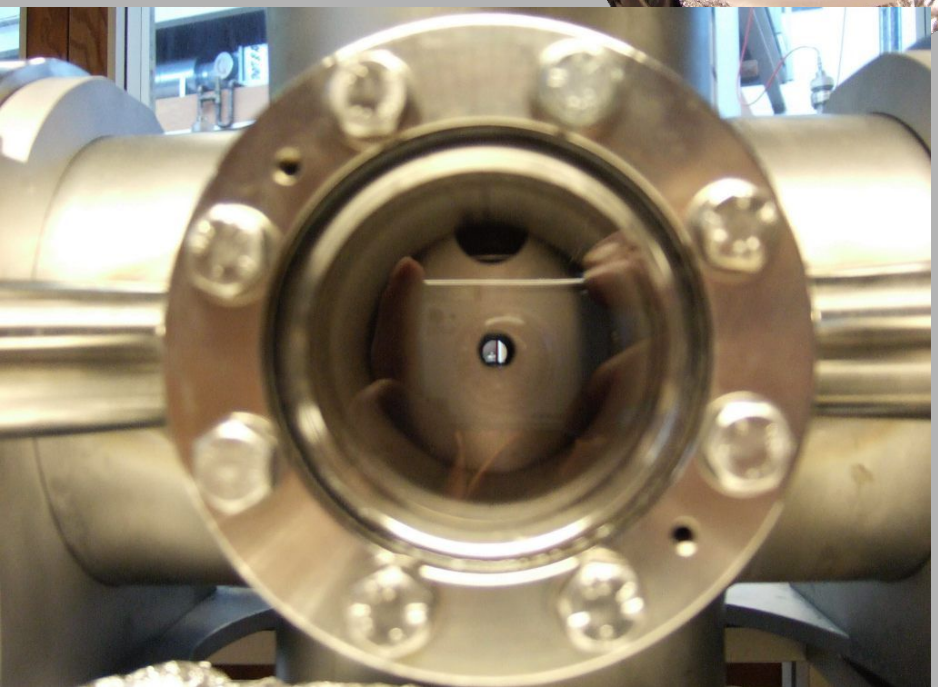
The first experiments

Lund 2009-10-15

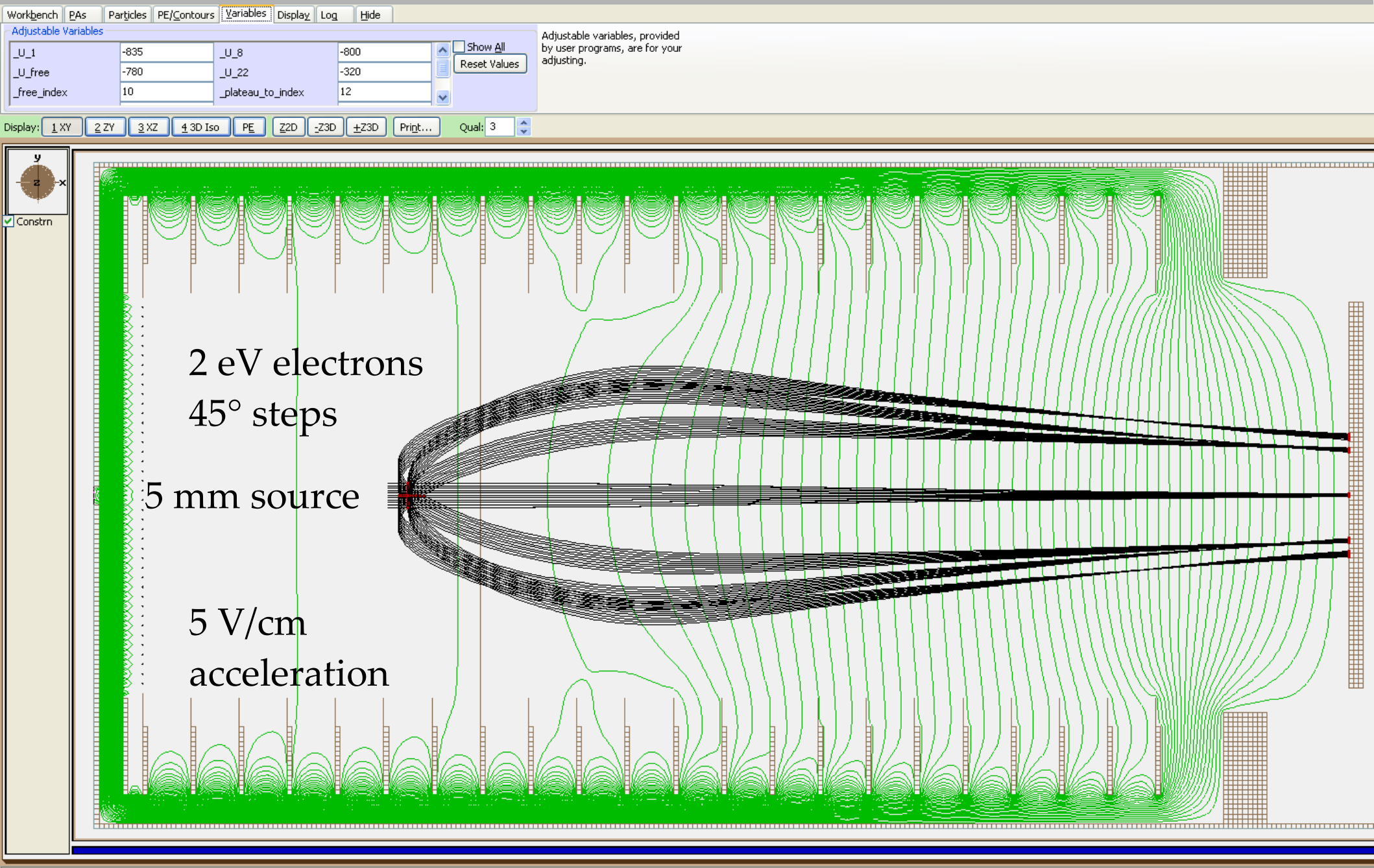




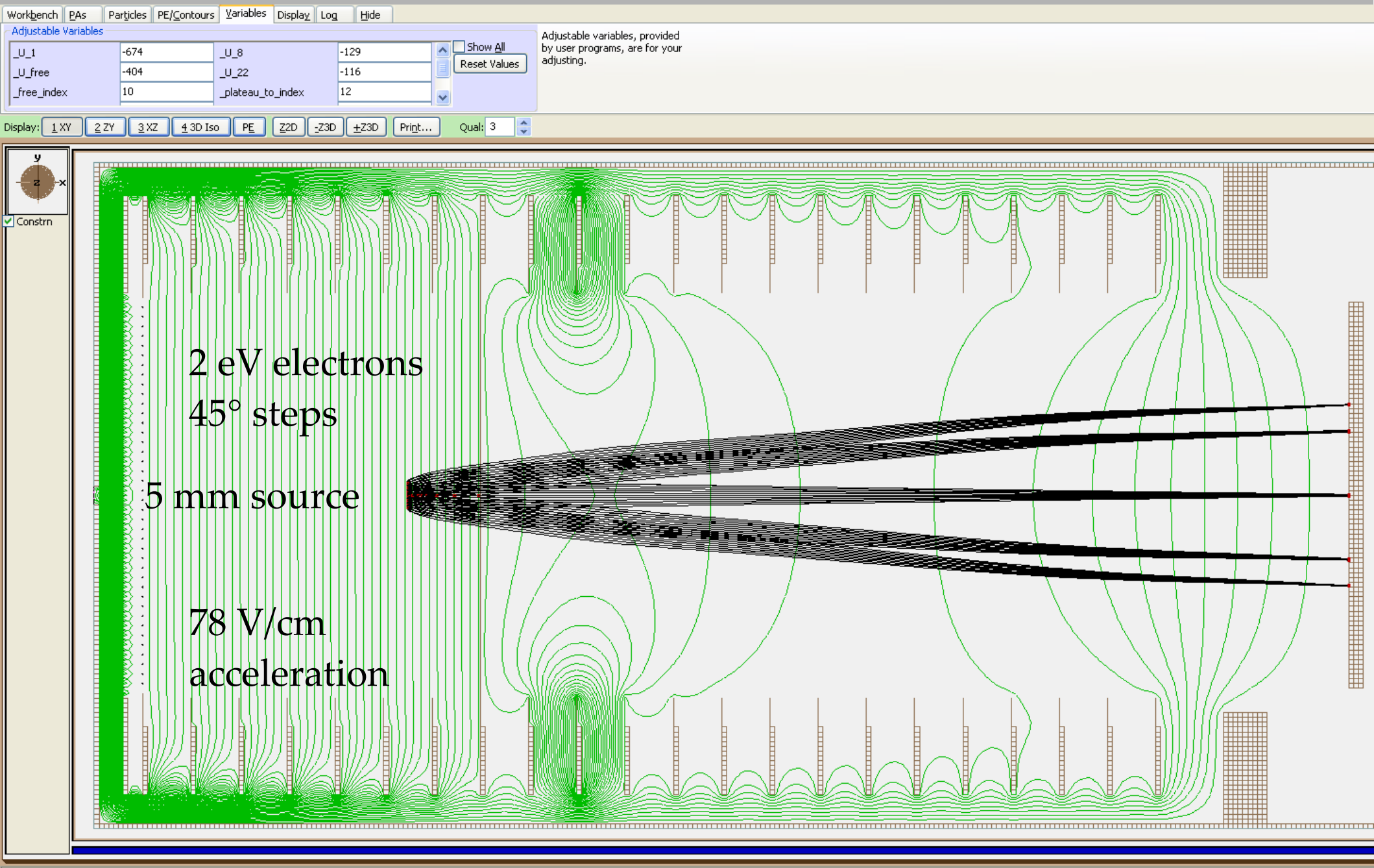

MCP & detector
go here



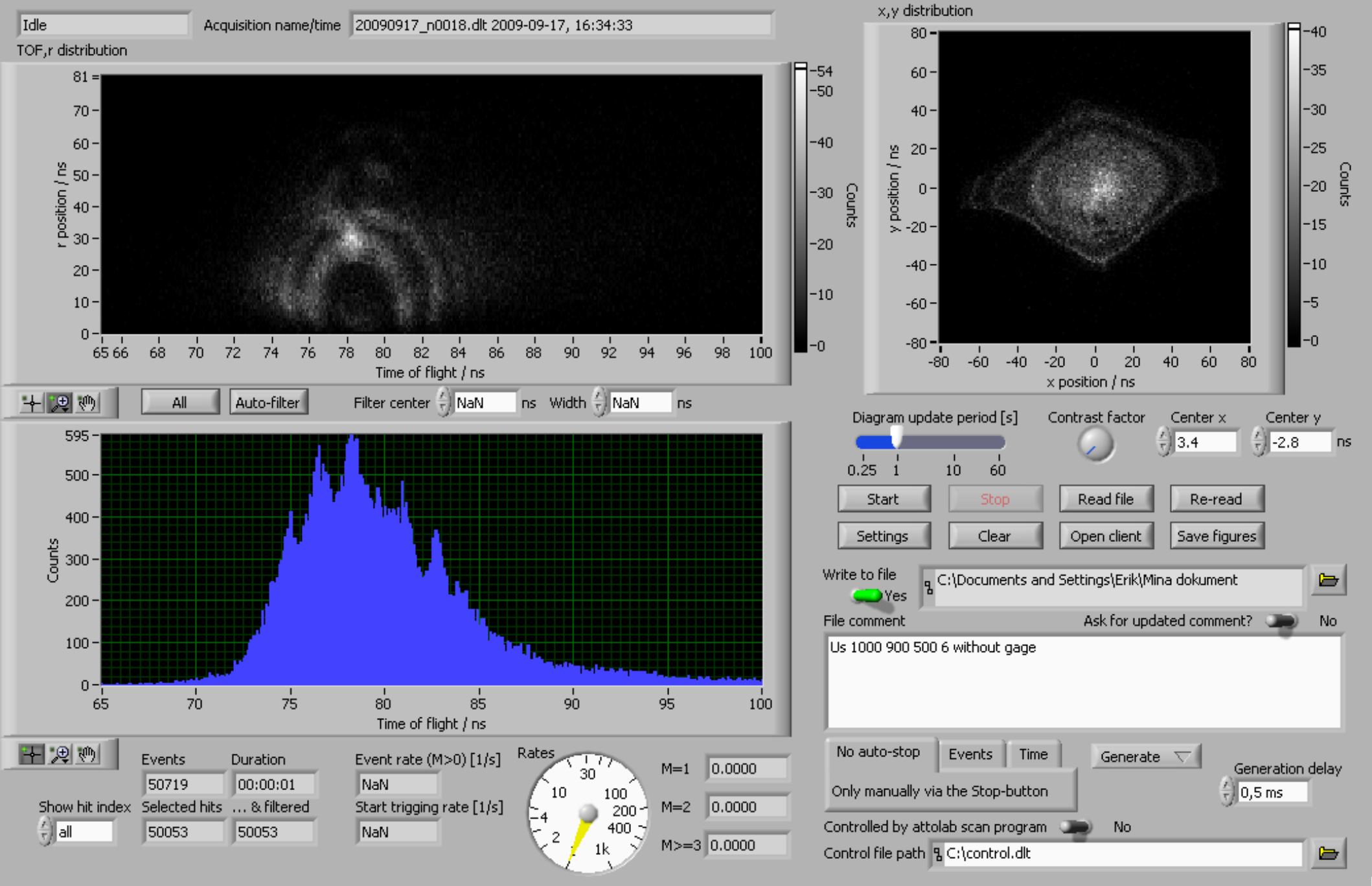
Electrostatic lens



Electrostatic lens



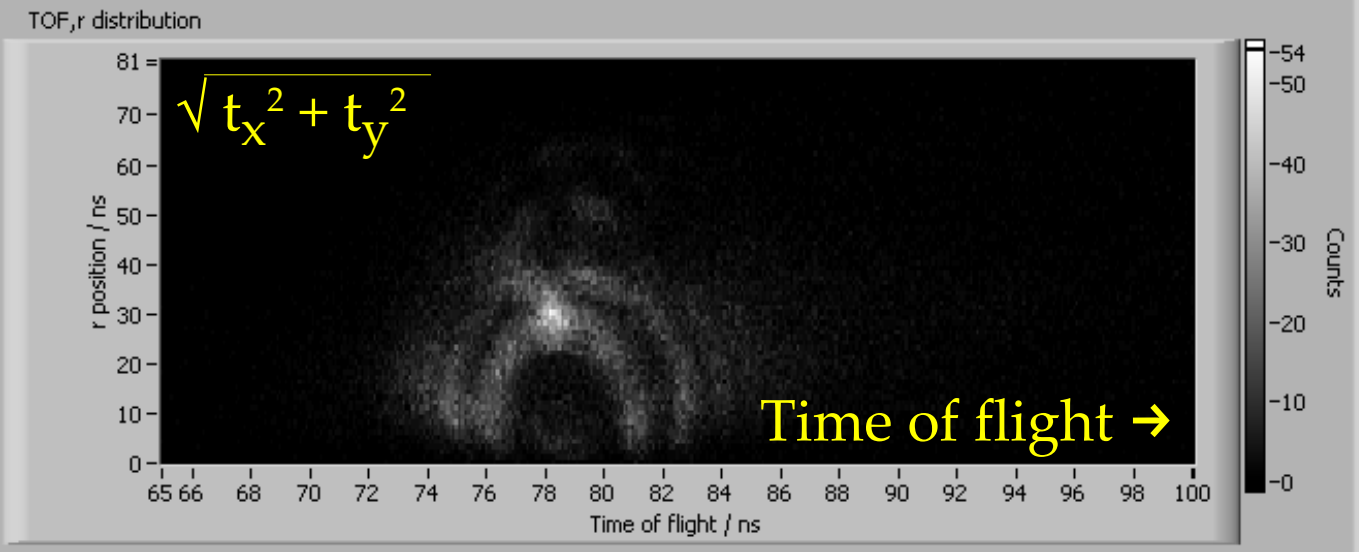
LabView program

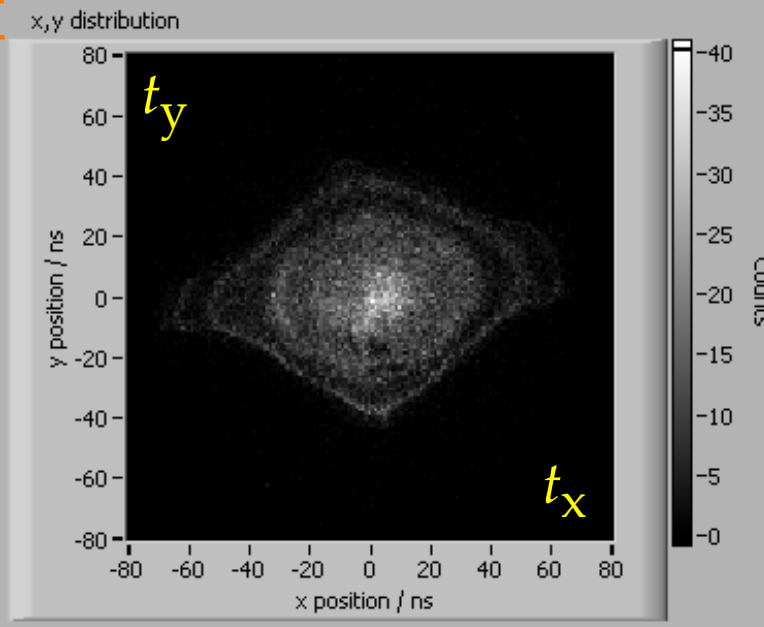


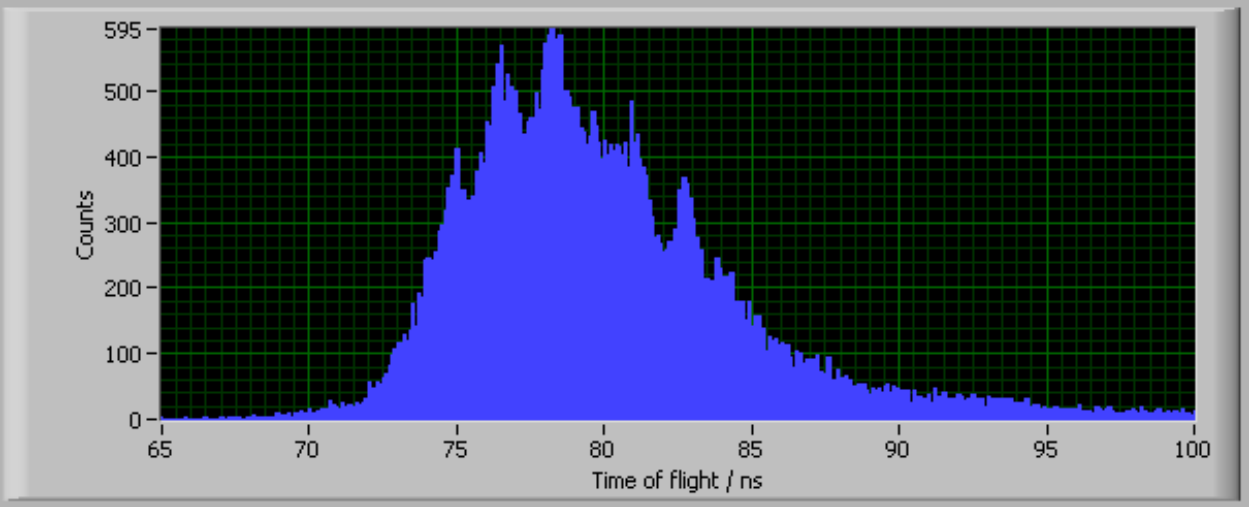
IR laser...

3 measured times

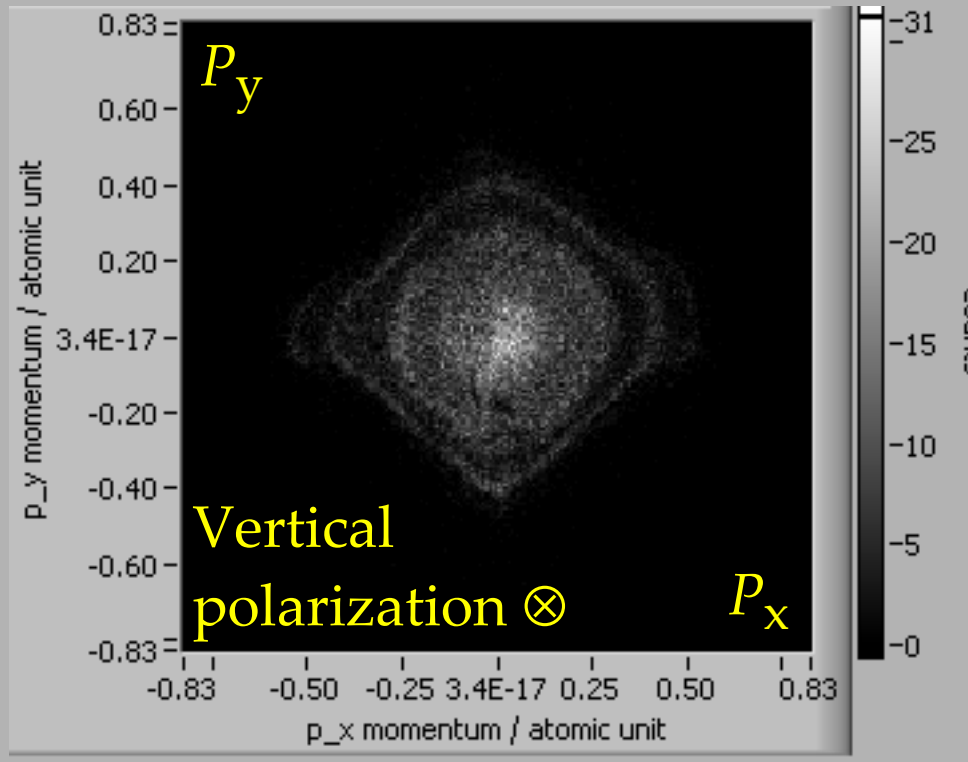
$Xe + n \cdot h\nu_{IR} \rightarrow Xe^+ + \underline{e^-}$

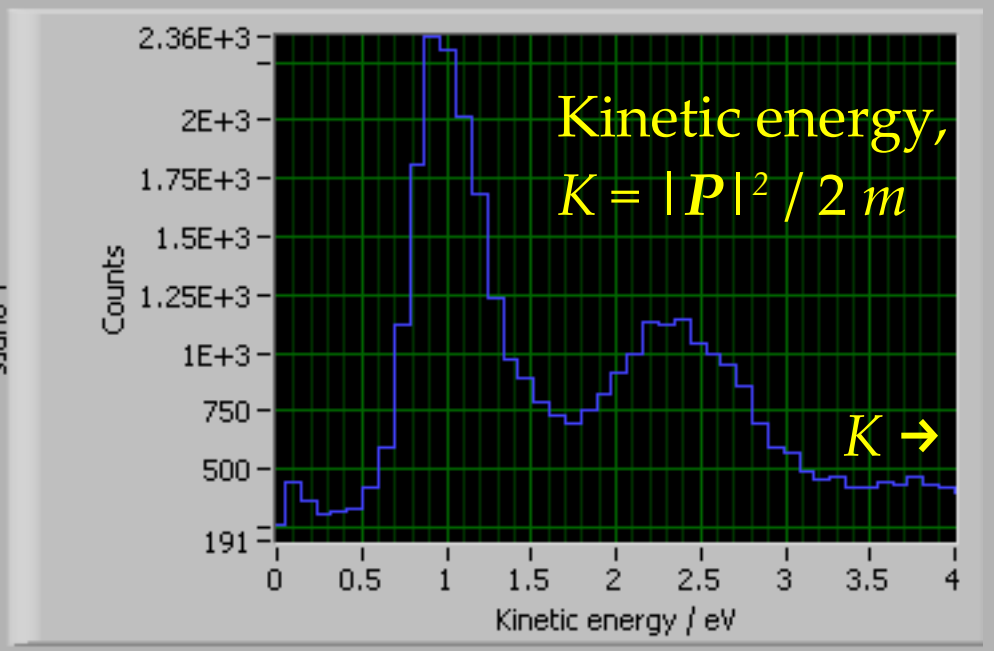




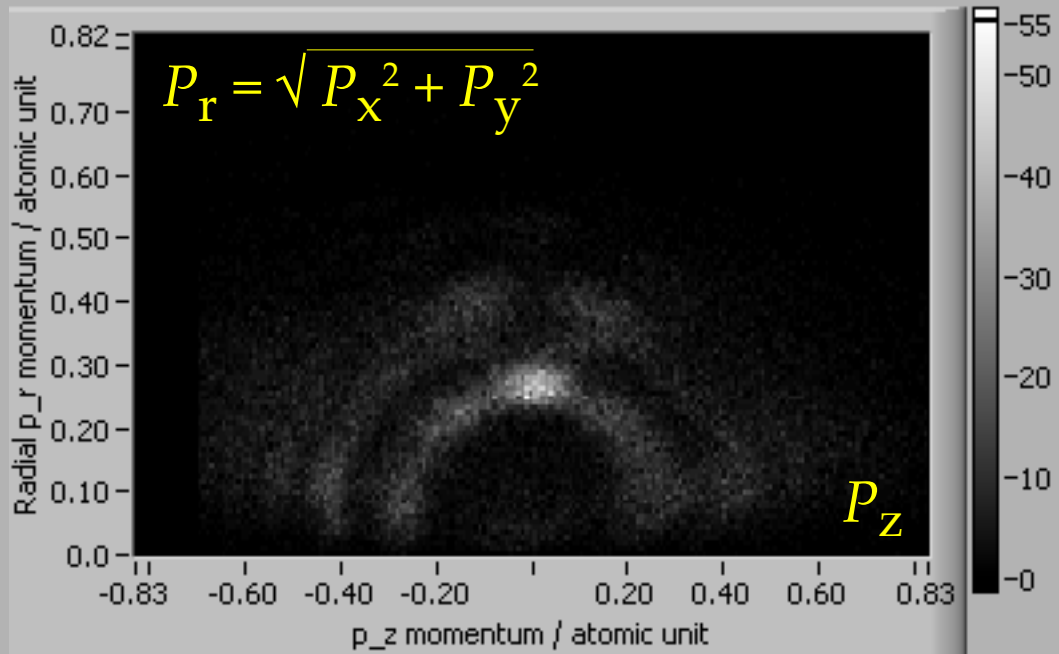


→ 3D Momentum & energy





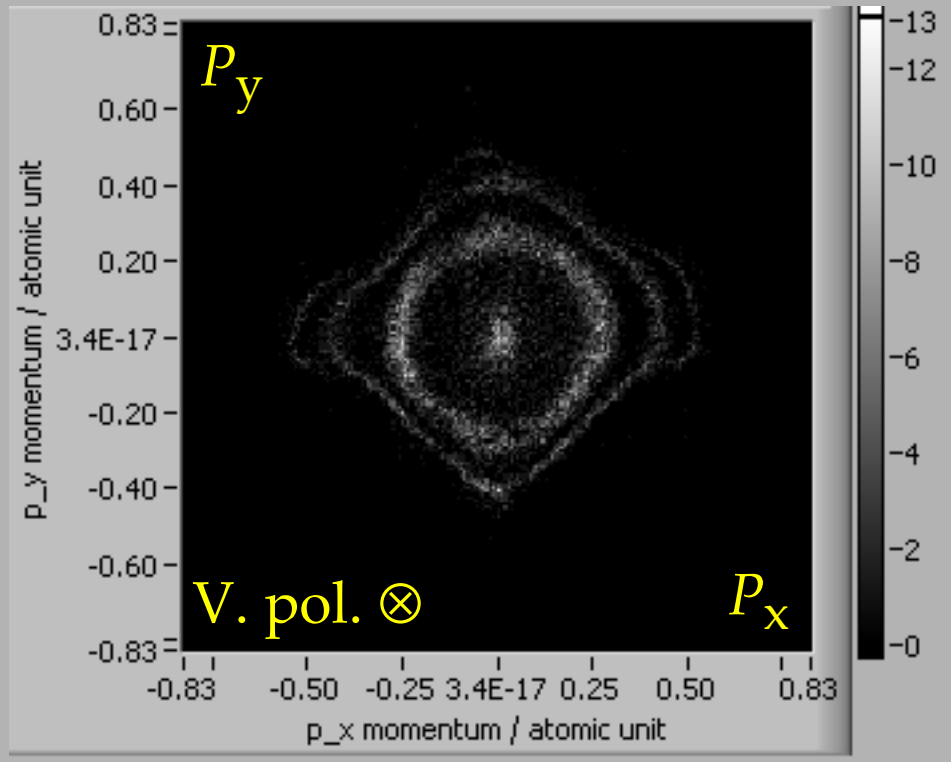
$Xe + n \cdot h\nu_{IR} \rightarrow Xe^+ + \underline{e^-}$

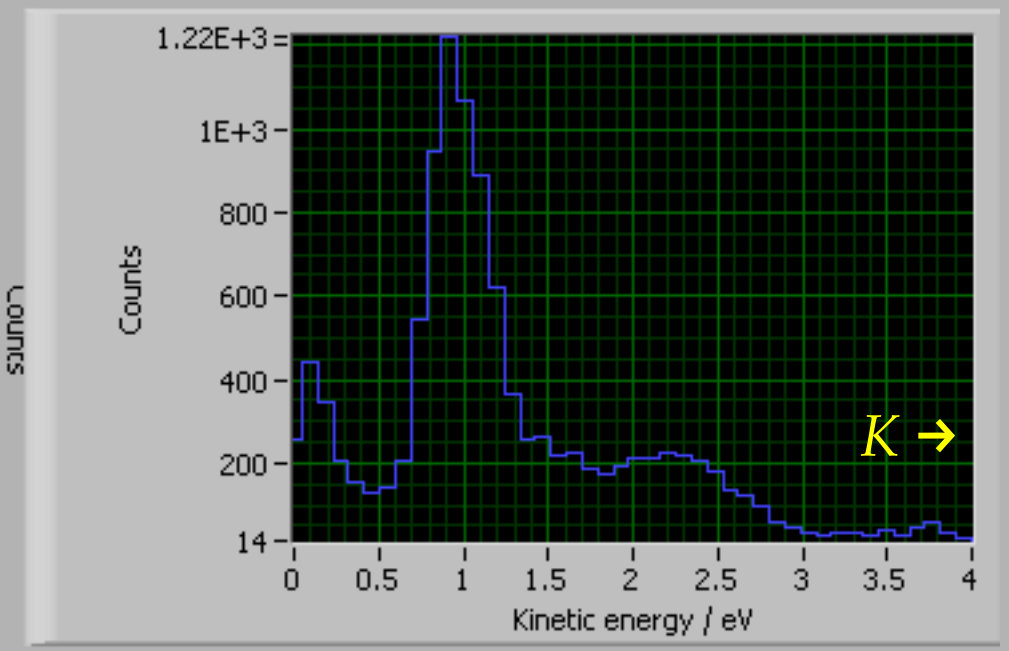


5:20 minutes, 0.16 hits per shot
Using 88% of 50k hits

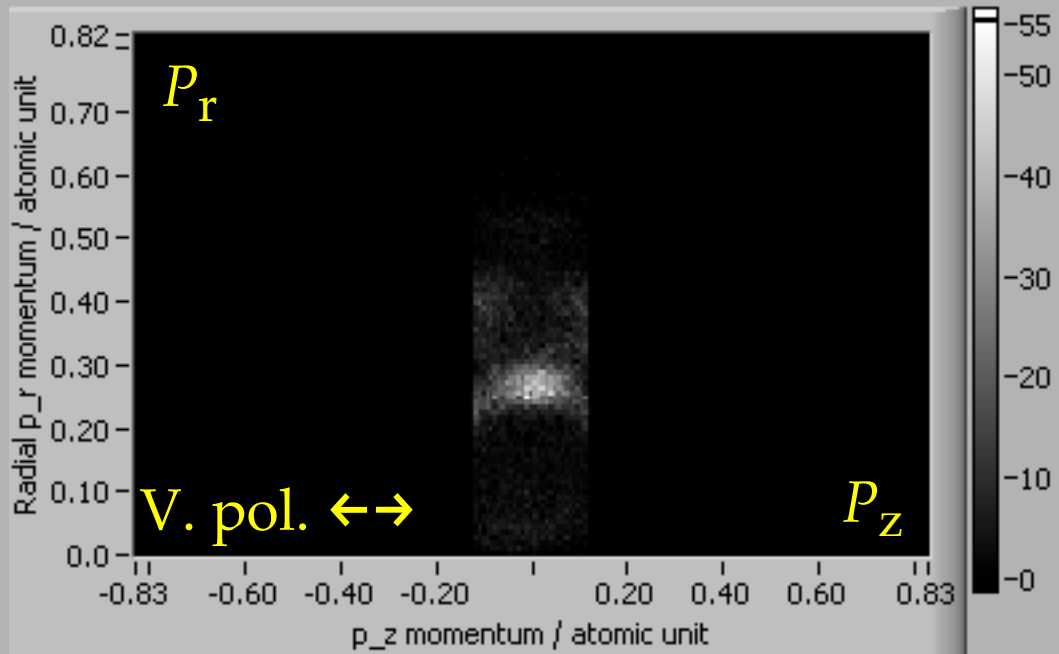
Vertical
polarization ↔

Filter for resolution



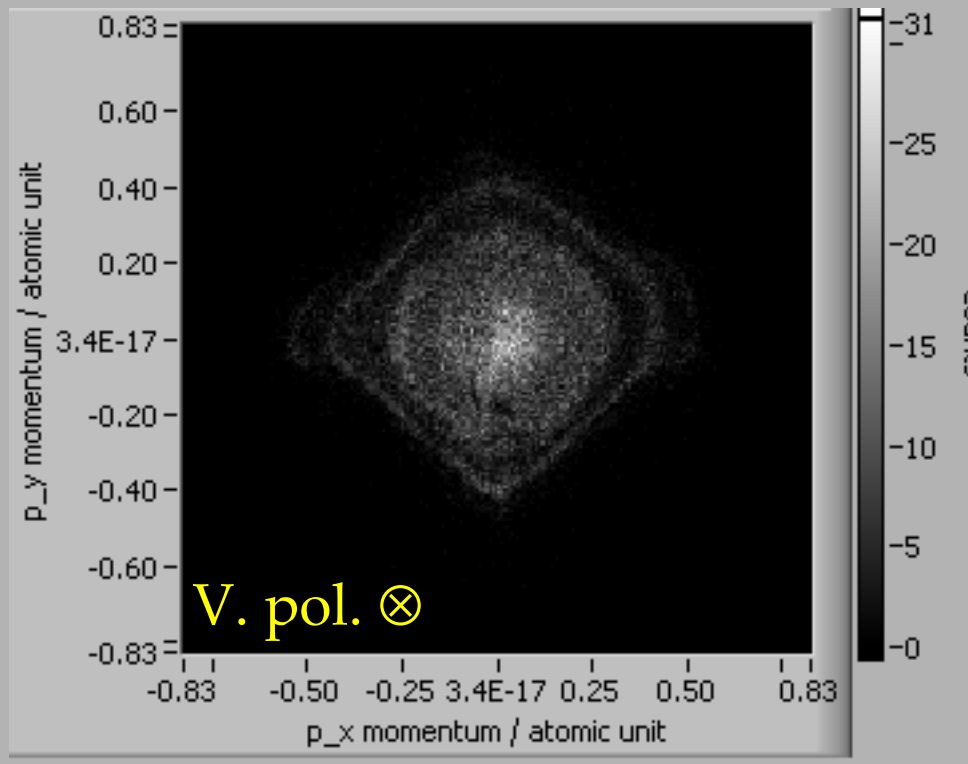


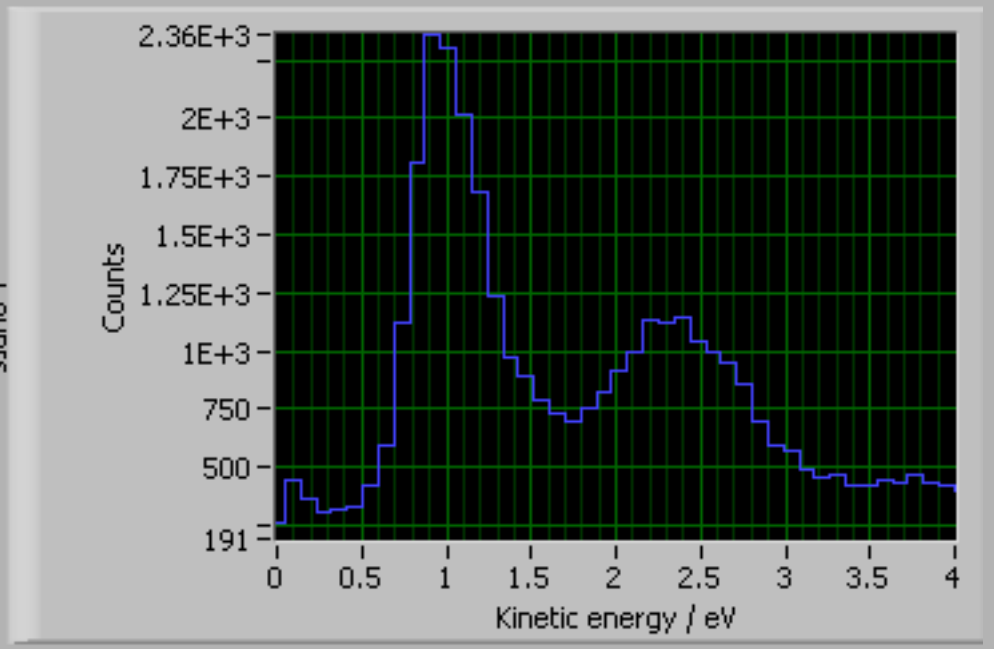
$Xe + n \cdot h\nu_{IR} \rightarrow Xe^+ + e^-$

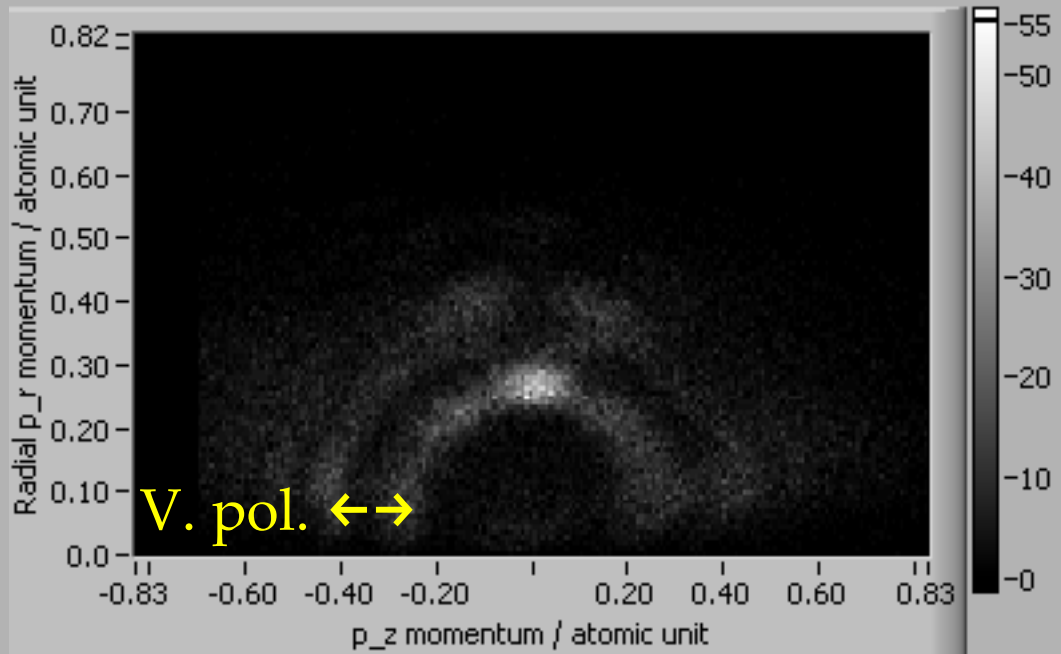


Same experiment & file,
only using slice where $|P_z| < 0.12$
Using 22% of 50k hits

Tuning ability



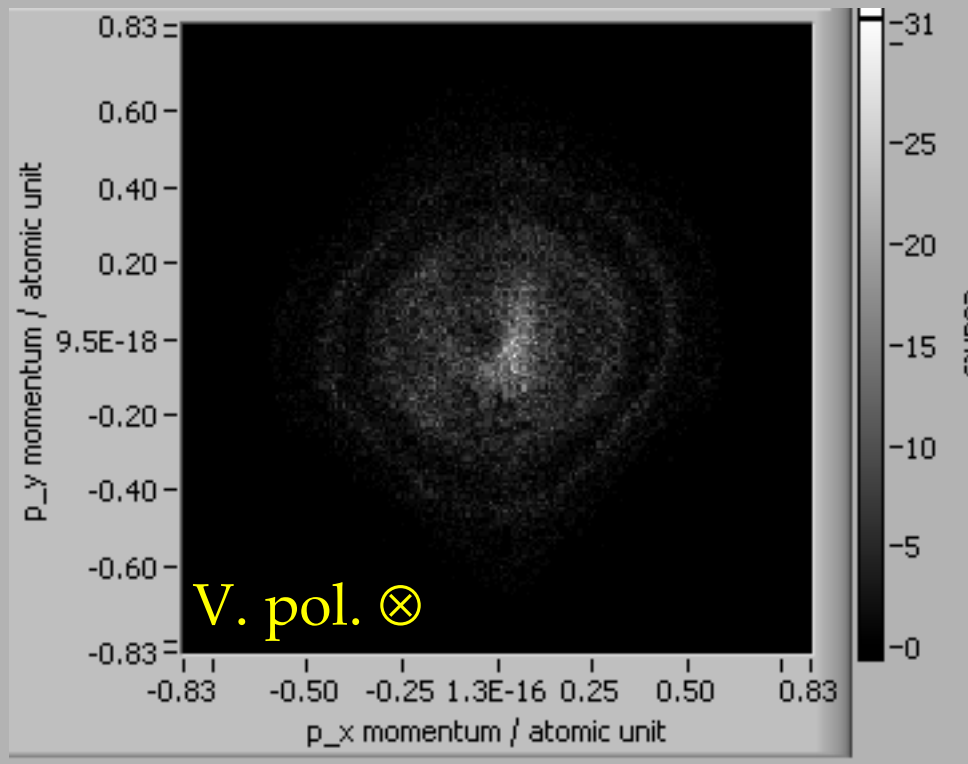


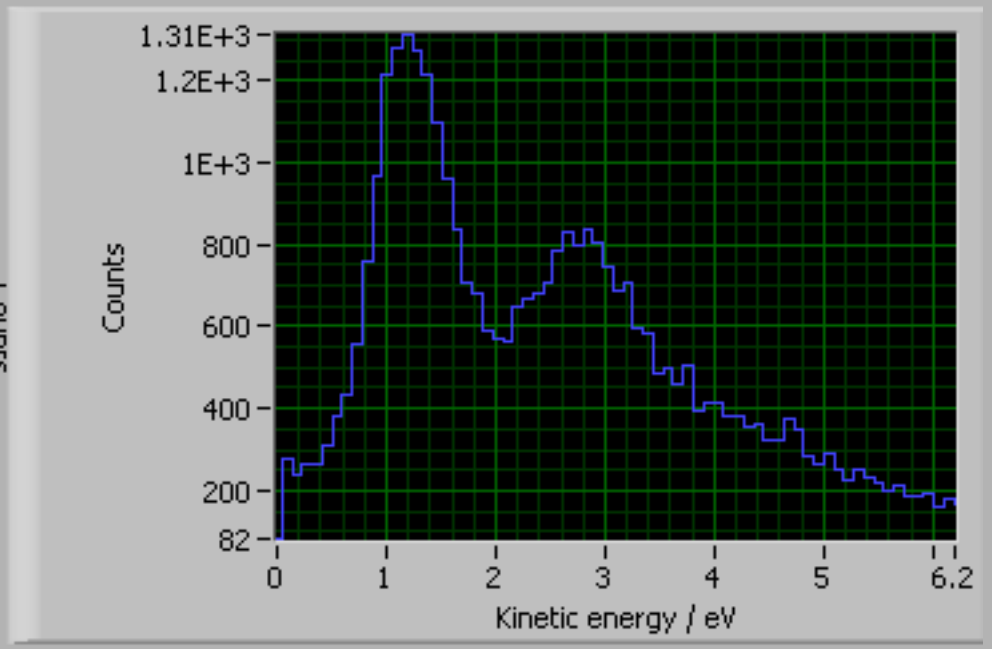


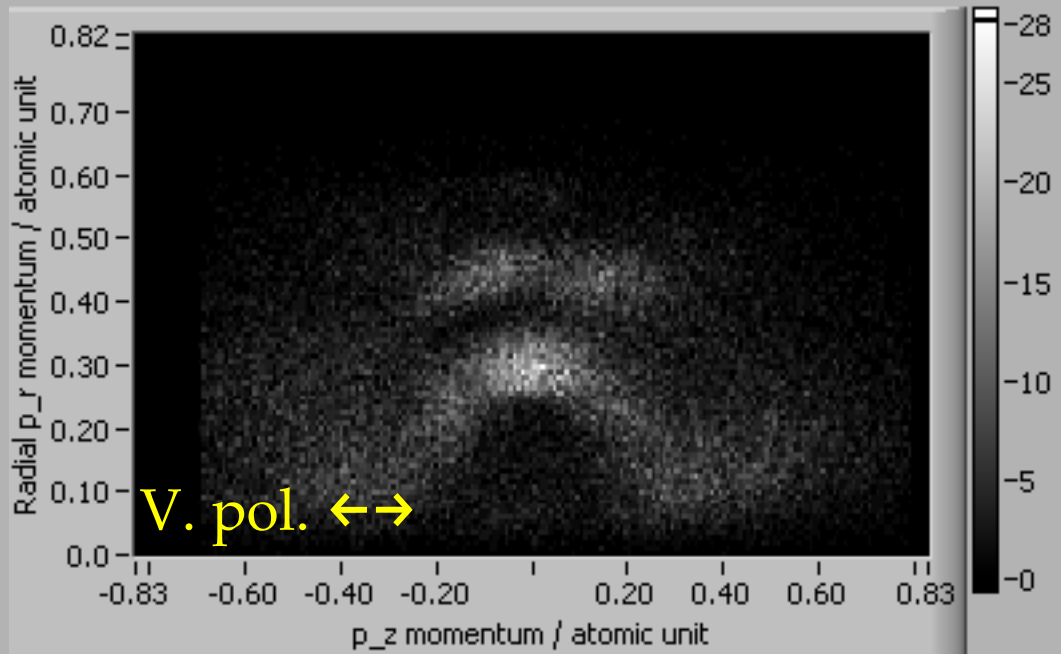
$Xe + n \cdot h\nu_{IR} \rightarrow Xe^+ + \underline{e^-}$

Electrode potentials:
-1000, -900, -500, -6 V

Different electrode setting







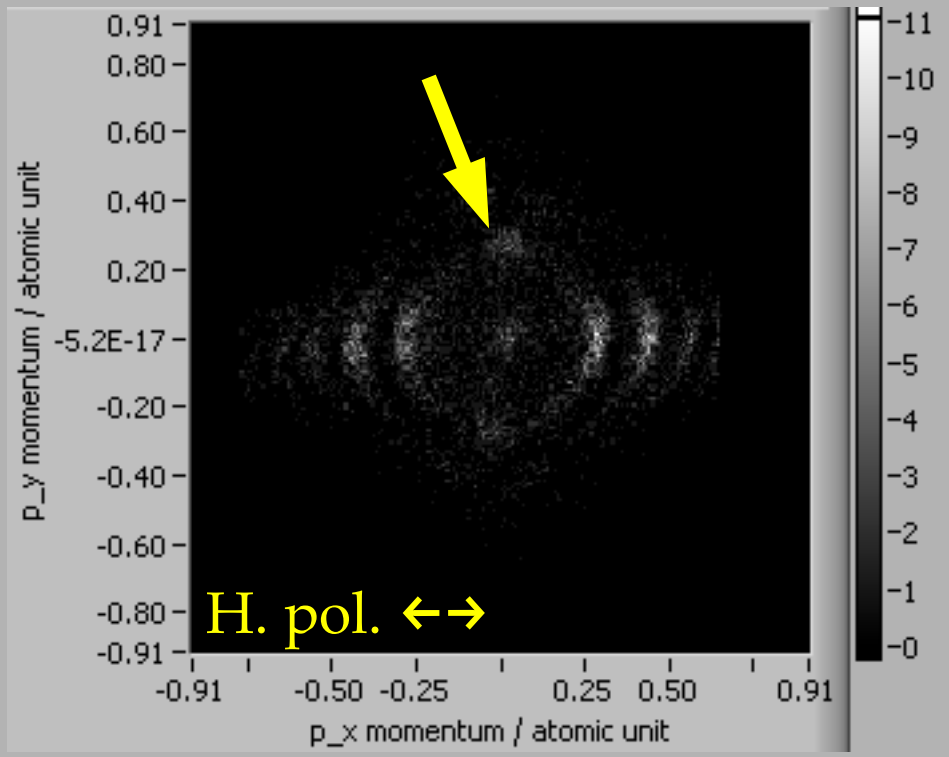
$Xe + n \cdot h\nu_{IR} \rightarrow Xe^+ + \underline{e^-}$

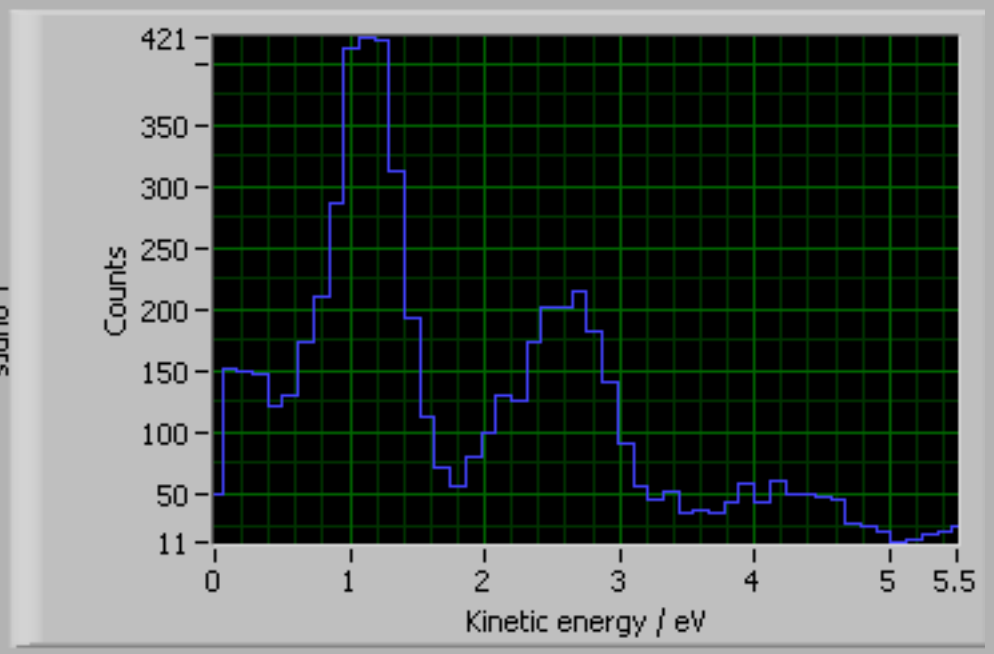
Same experiment.
Different acceleration & lens
- Destroys time-of-flight info
- Perhaps prettier x,y-rings

Electrode potentials:
-1000, -800, -72, -6 V

Ponderomotive shift

$$Xe + n \cdot h\nu_{IR} \rightarrow Xe^{+} + e^{-}$$

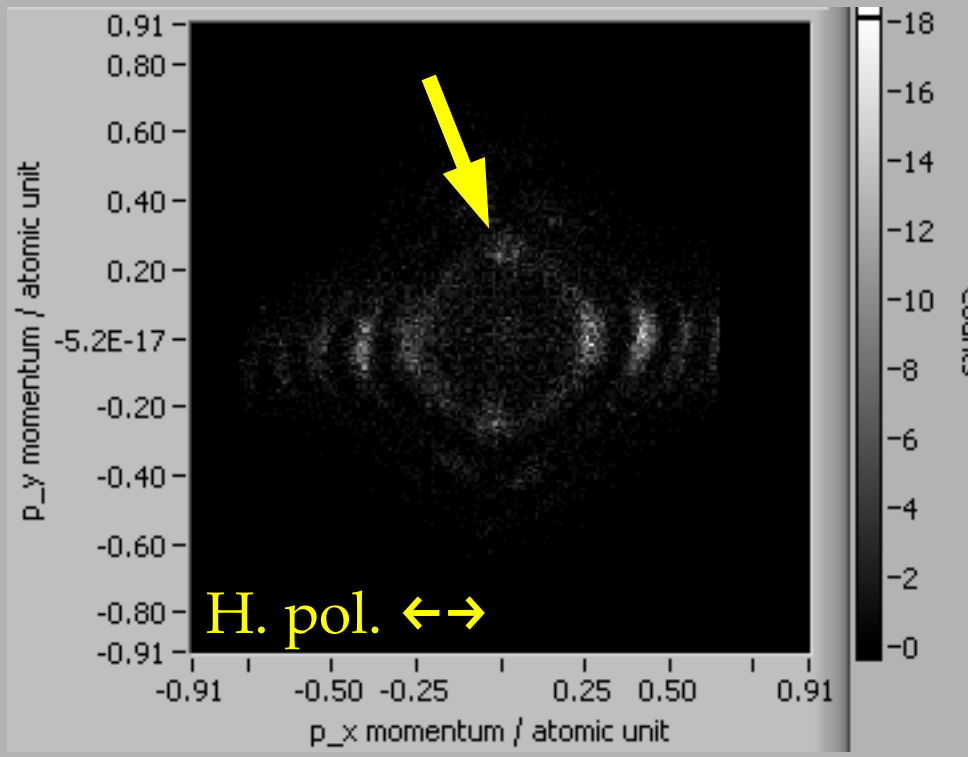


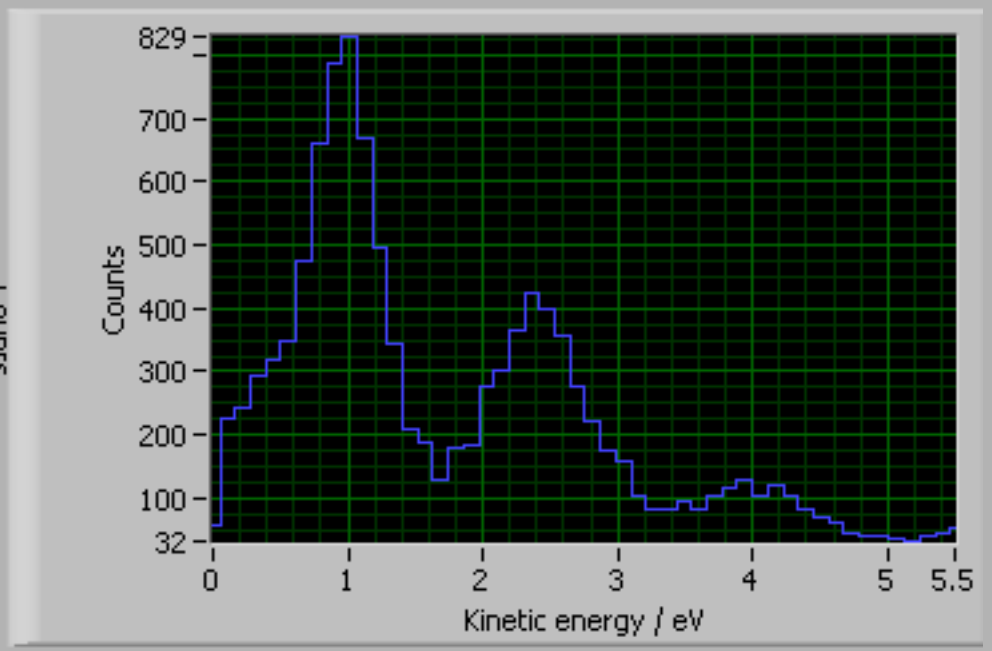


Weak IR (~ 5×10^{12} W/cm^2)

Ponderomotive shift

$$Xe + n \cdot h\nu_{IR} \rightarrow Xe^{+} + \underline{e^{-}}$$

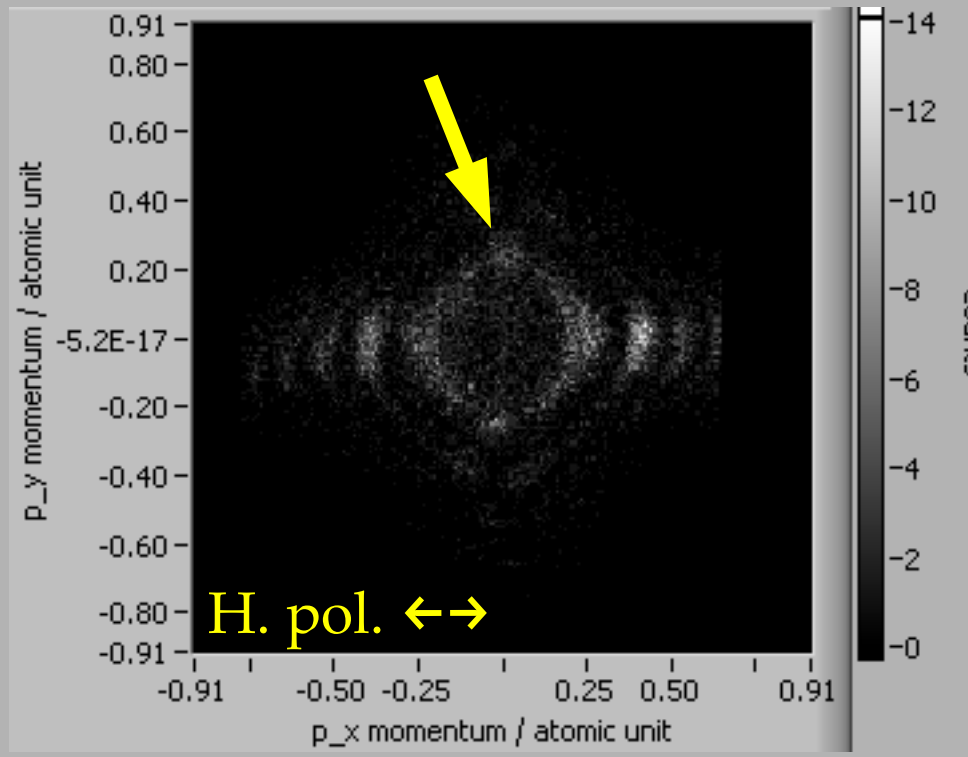


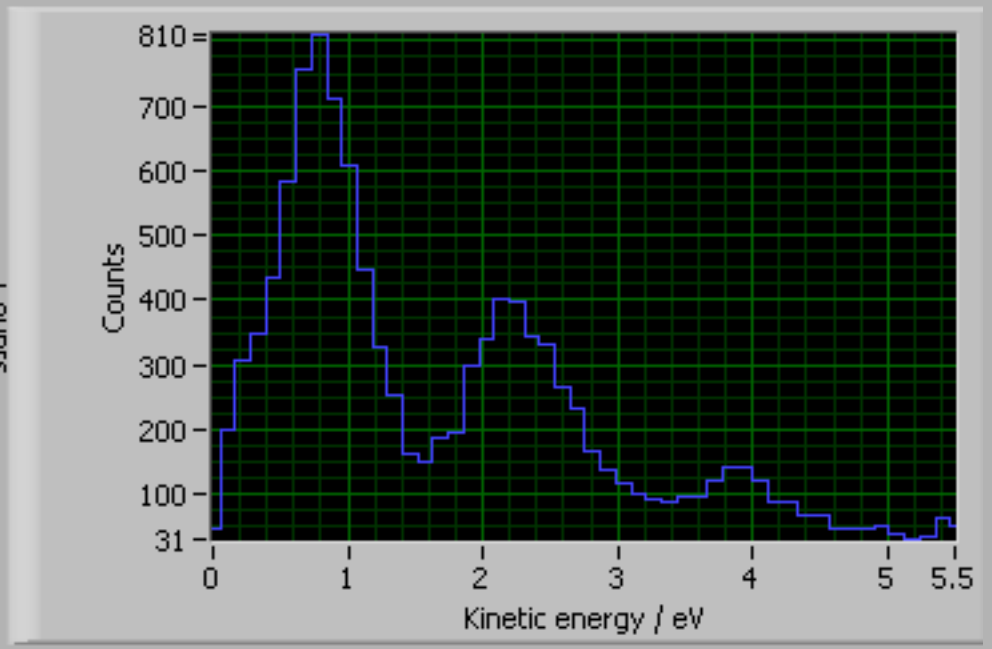


Increasing IR

Ponderomotive shift

$$Xe + n \cdot h\nu_{IR} \rightarrow Xe^{+} + \underline{e^{-}}$$

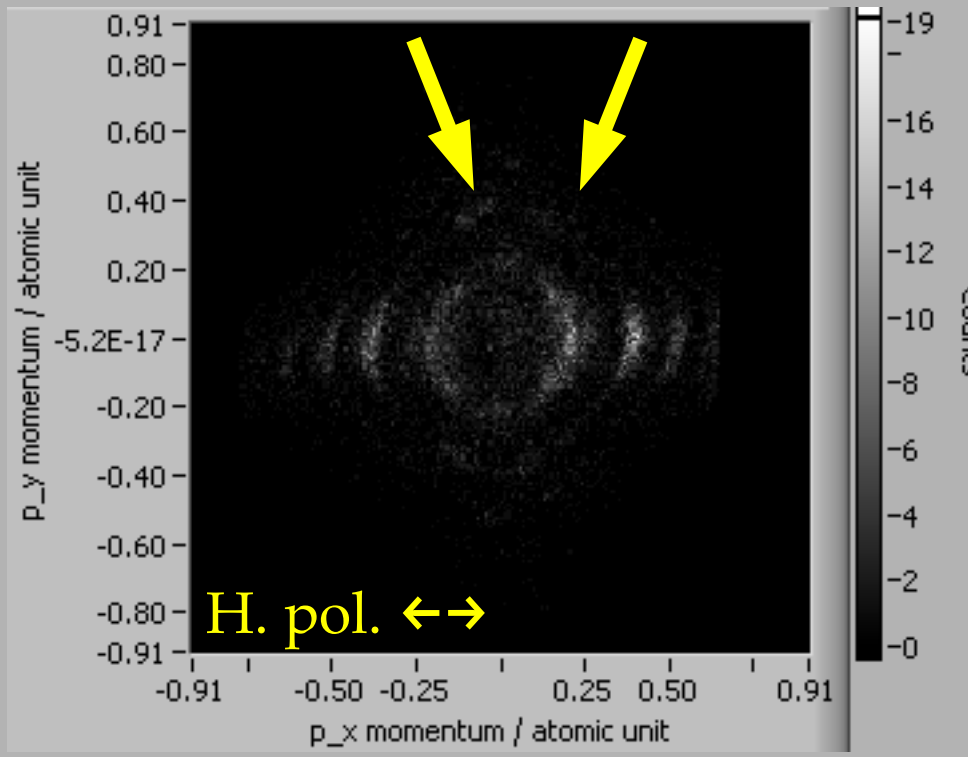


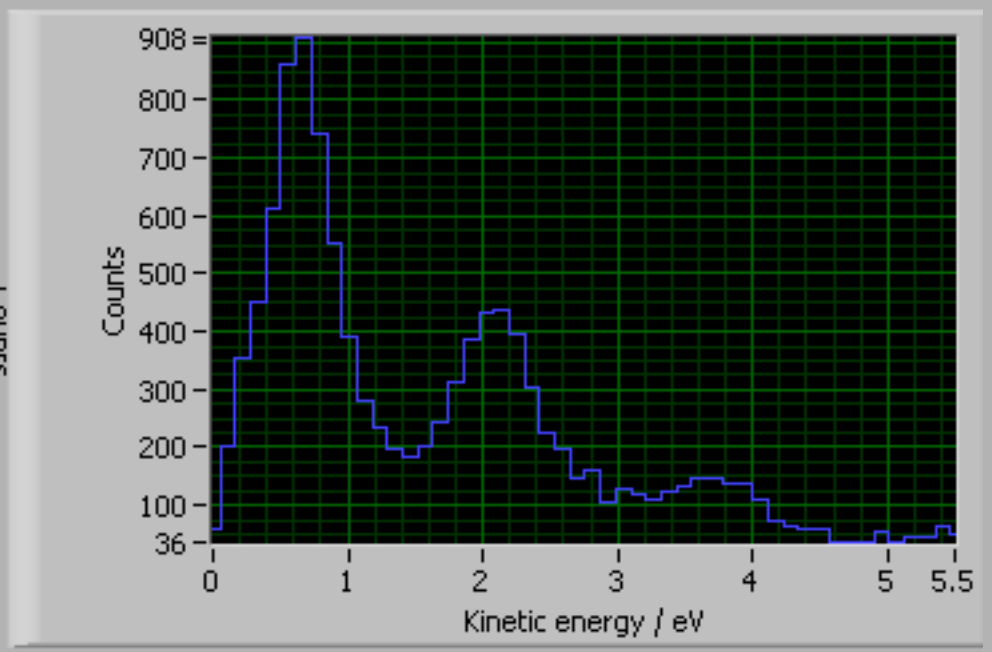


Increasing IR

Ponderomotive shift

$$Xe + n \cdot h\nu_{IR} \rightarrow Xe^{+} + \underline{e^{-}}$$

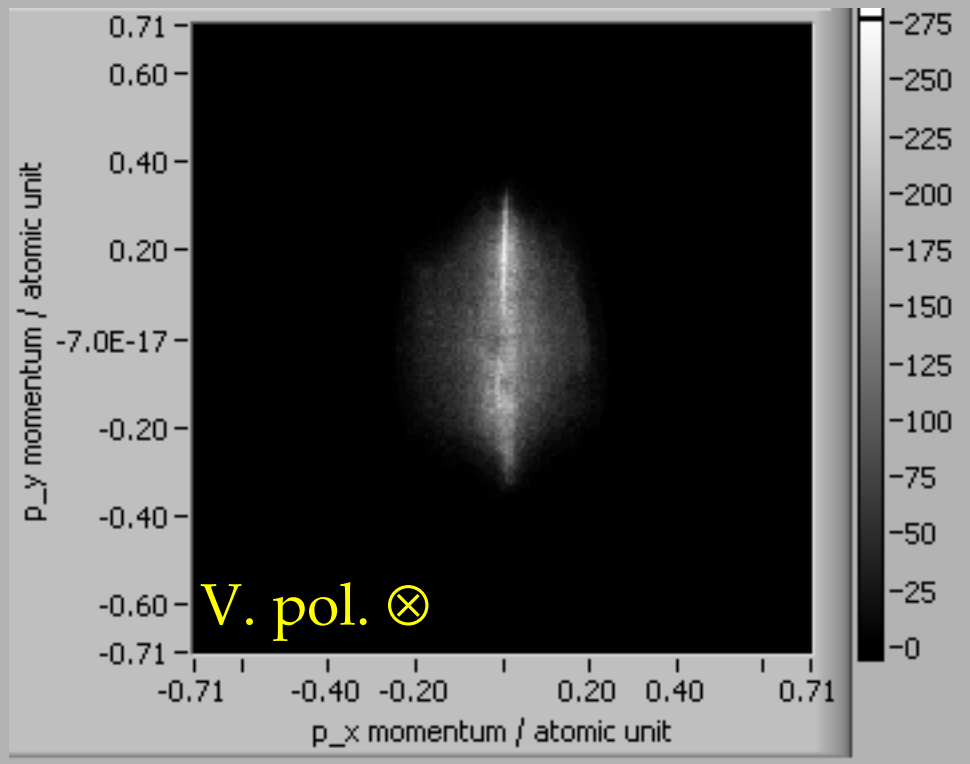


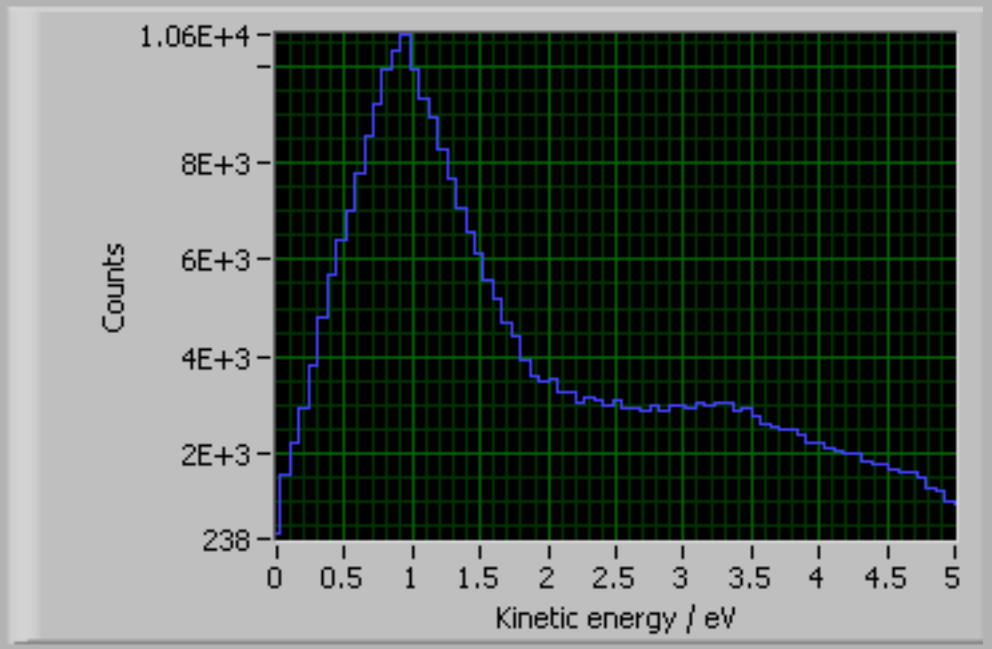


Strong IR (~ 1×10^{13} W/cm^2)

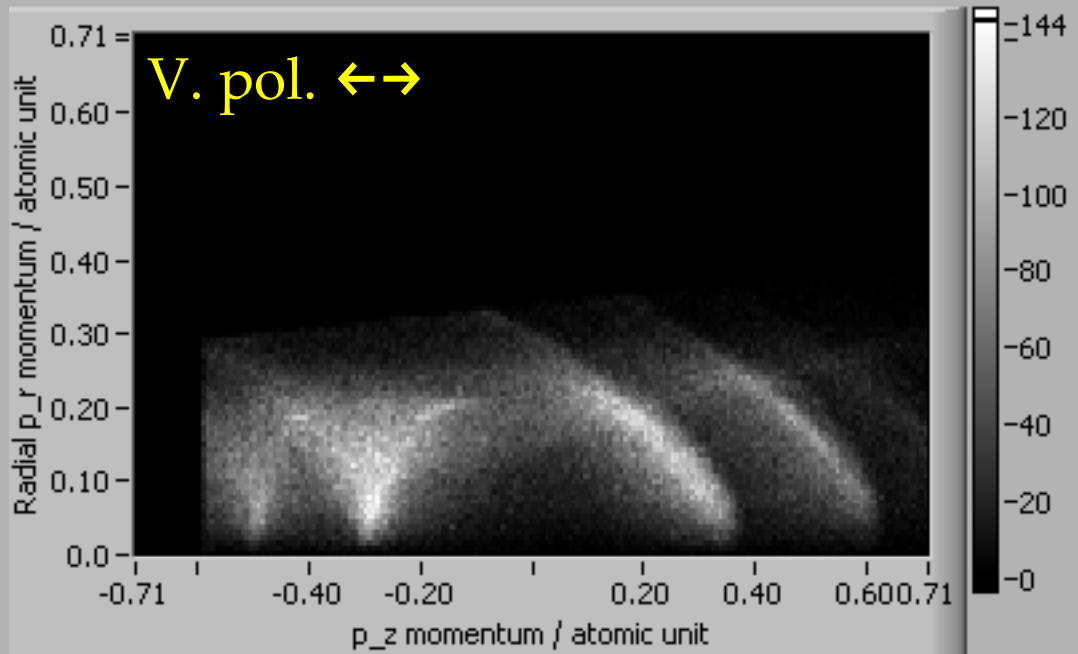
Now for HHG…

Problem: source volume



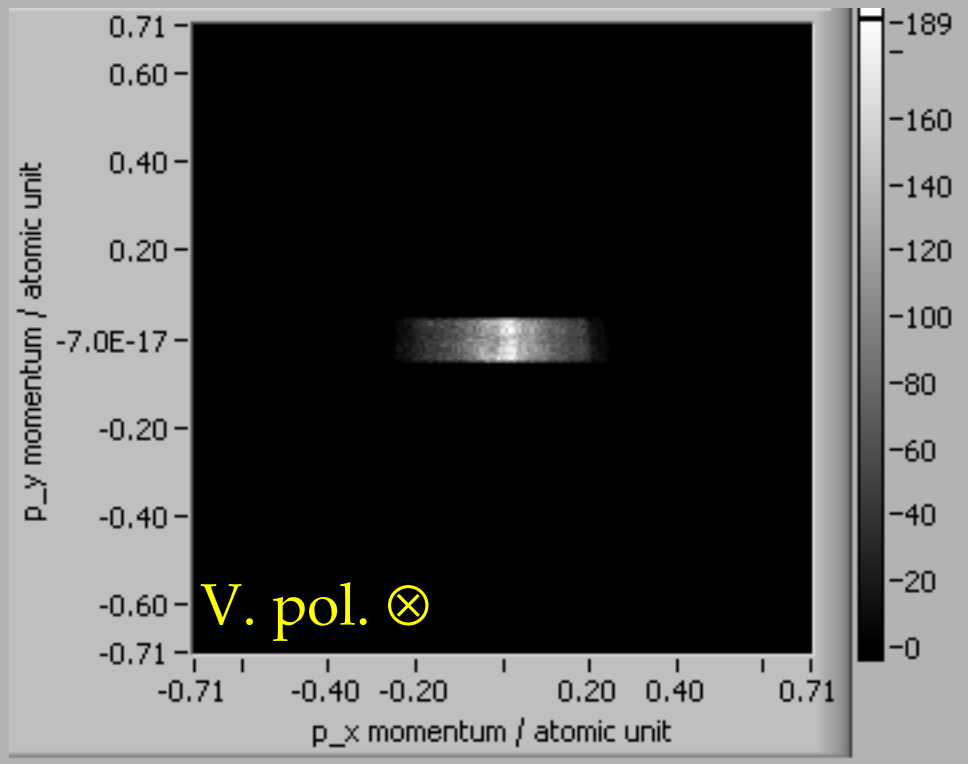


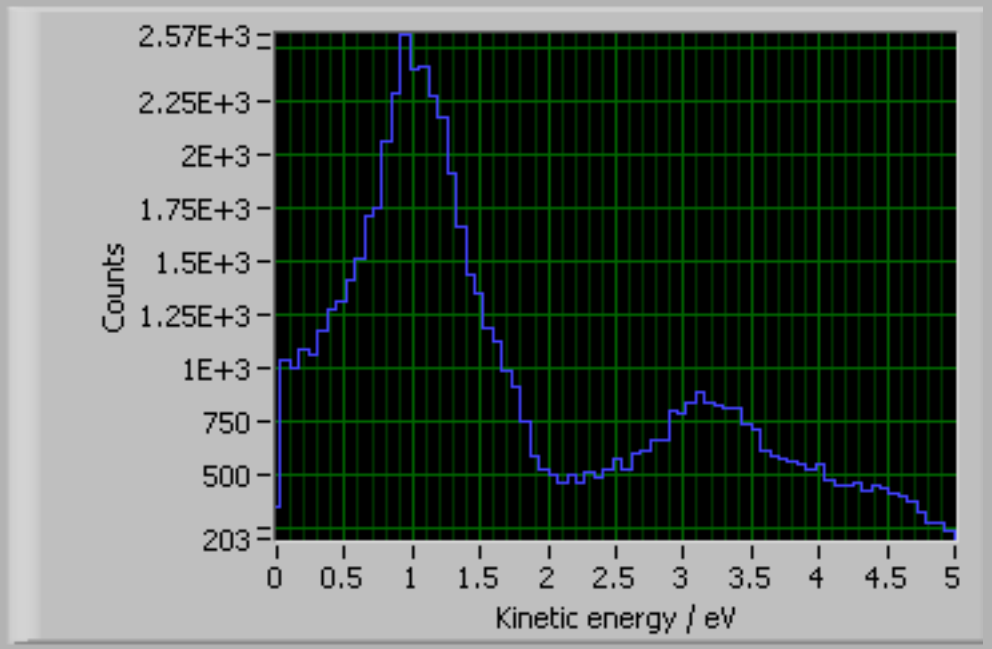
$He + h\nu_{HHG} \rightarrow He^+ + \underline{e^-}$



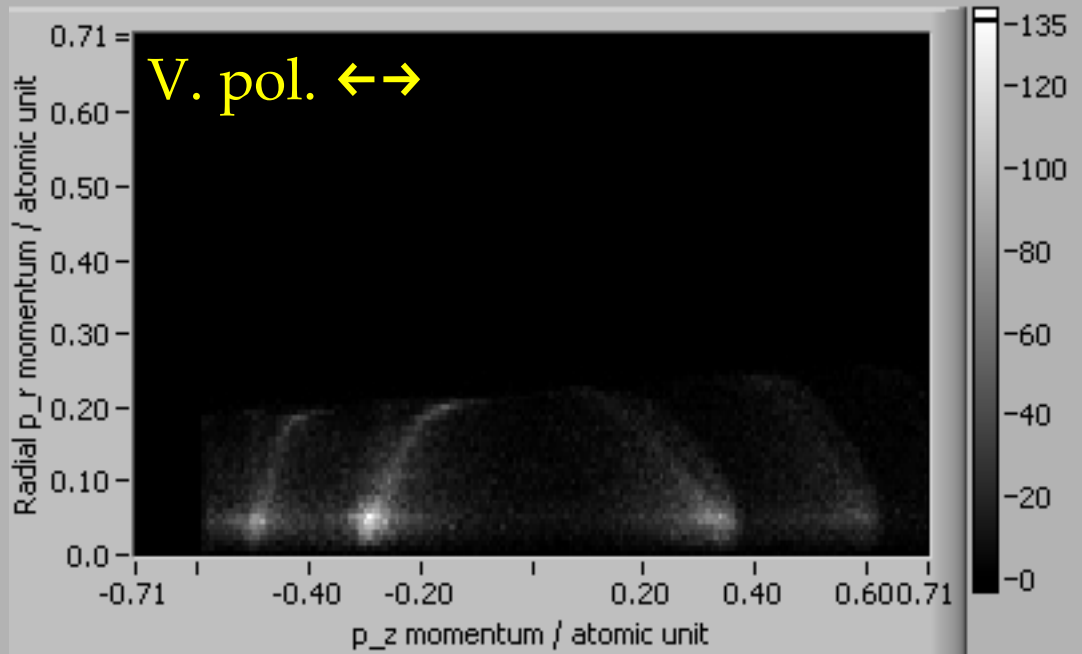
No extra filter
Using 77% of 400k hits
Acquired during 10 minutes
(0.6 hits per shot)

Problem: source volume





$He + h\nu_{HHG} \rightarrow He^+ + \underline{e^-}$



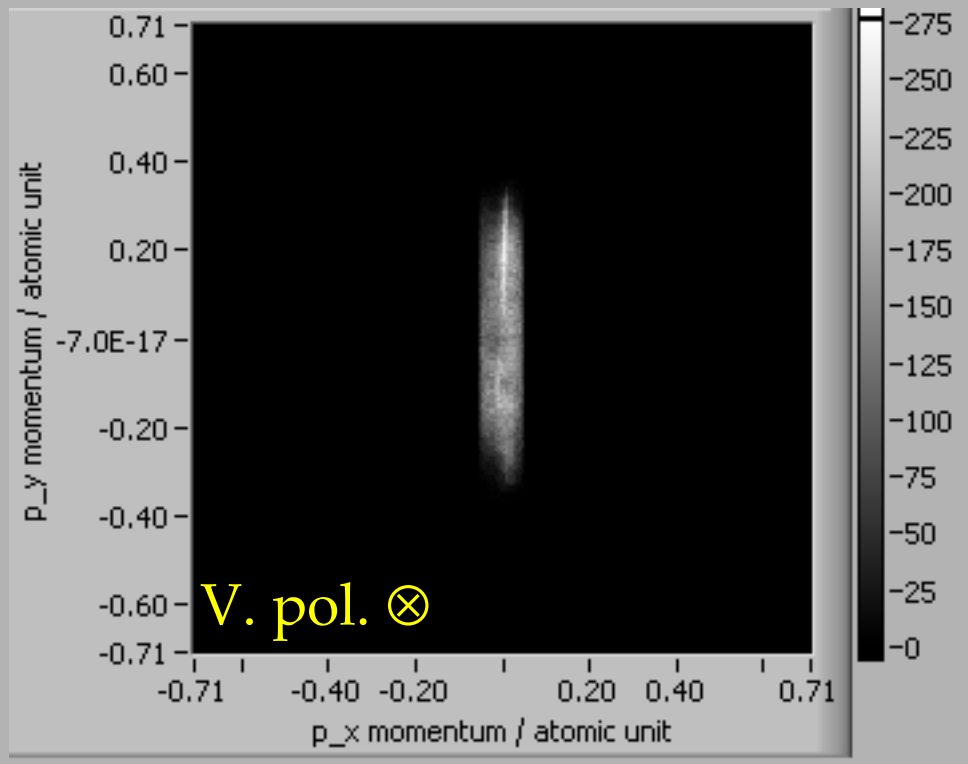
Filter on $|P_y| < 0.05$

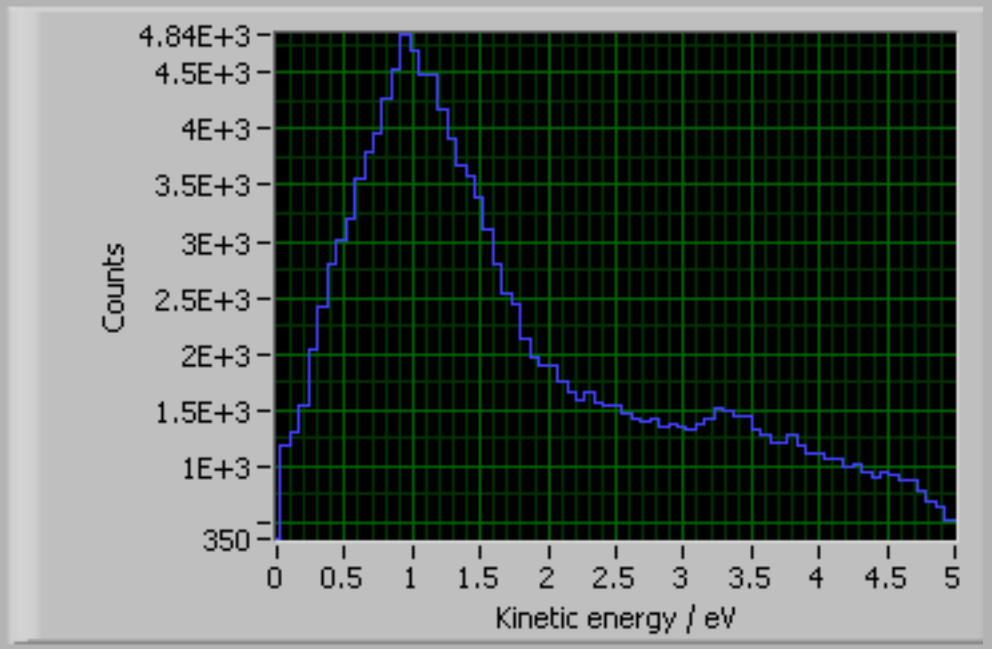
Using 18% of 400k hits

The source (focus) is extended along y-axis.

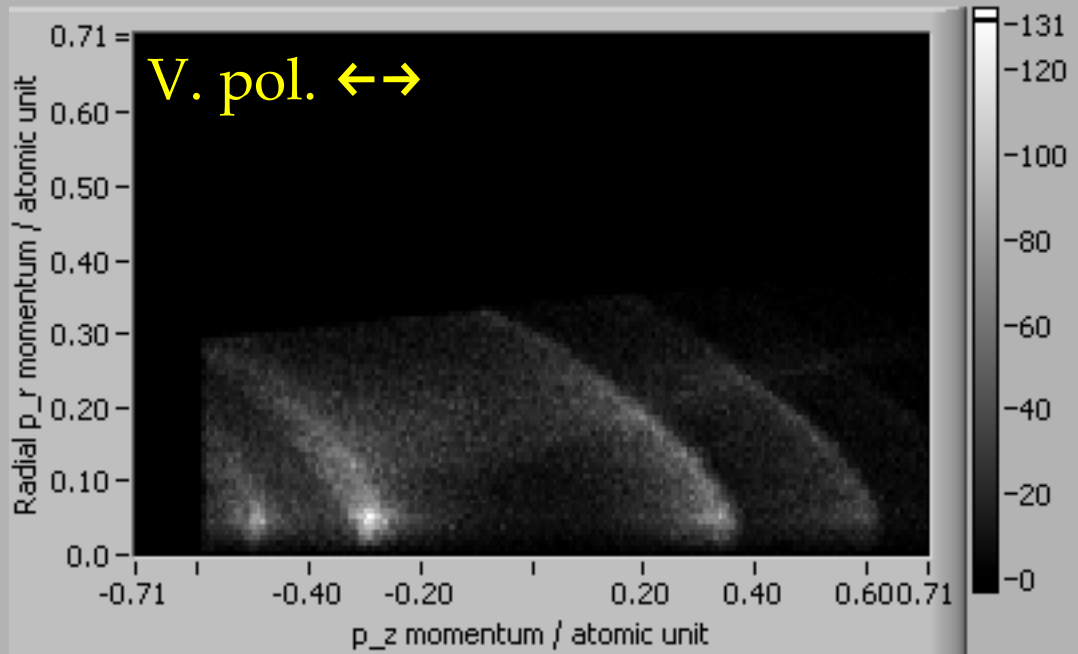
By looking at the x-component we avoid much blur.

Problem: source volume





$He + h\nu_{HHG} \rightarrow He^+ + \underline{e^-}$

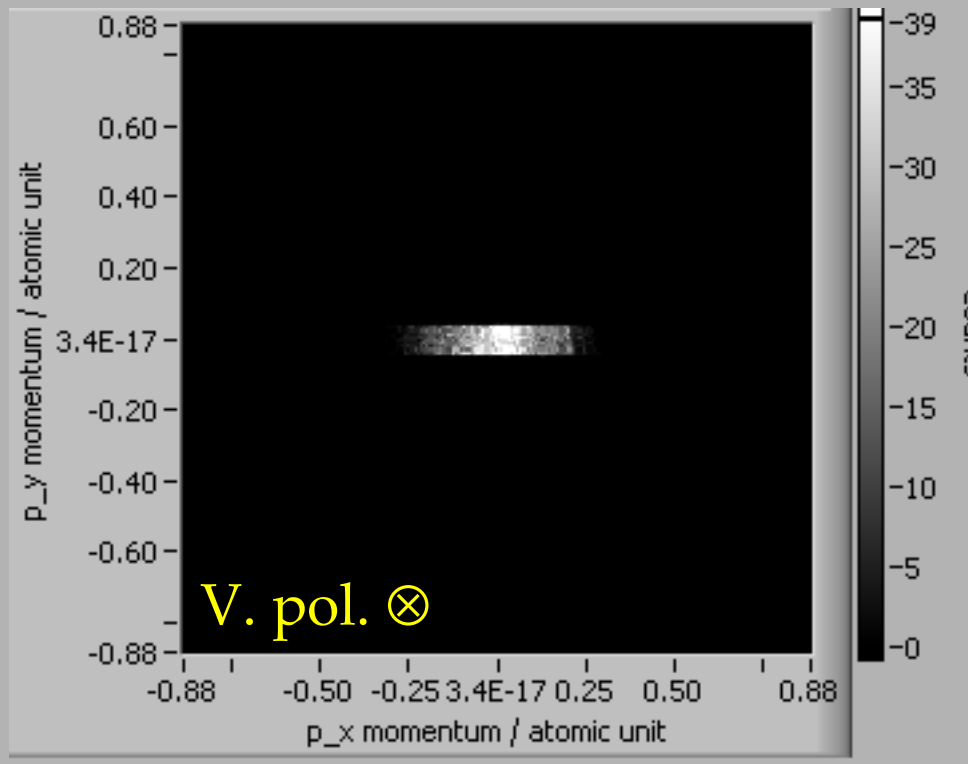


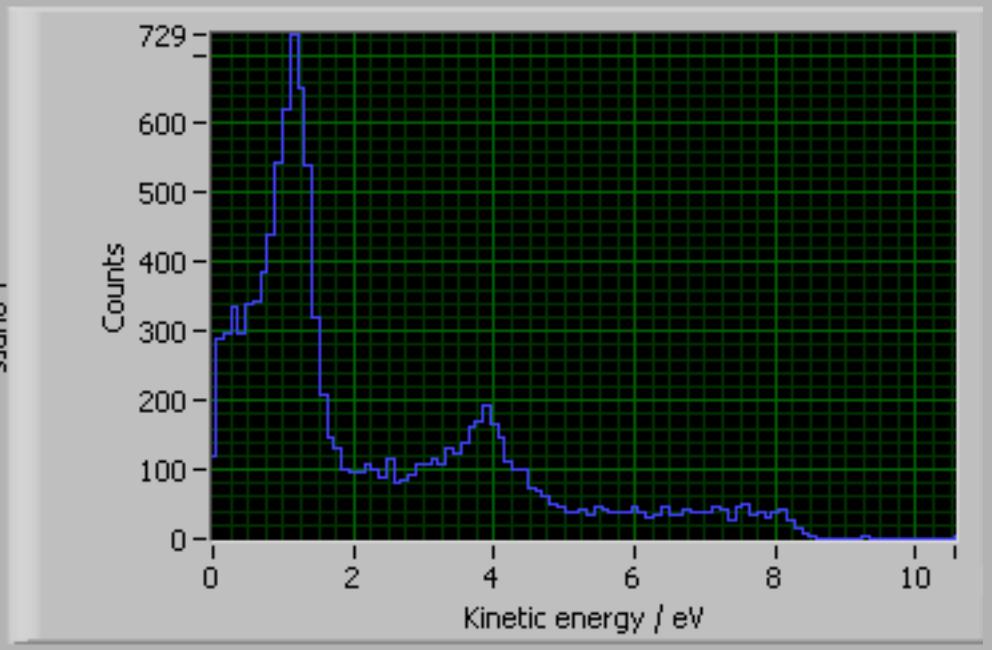
Filter on $|P_x| < 0.05$

Using 38% of 400k hits

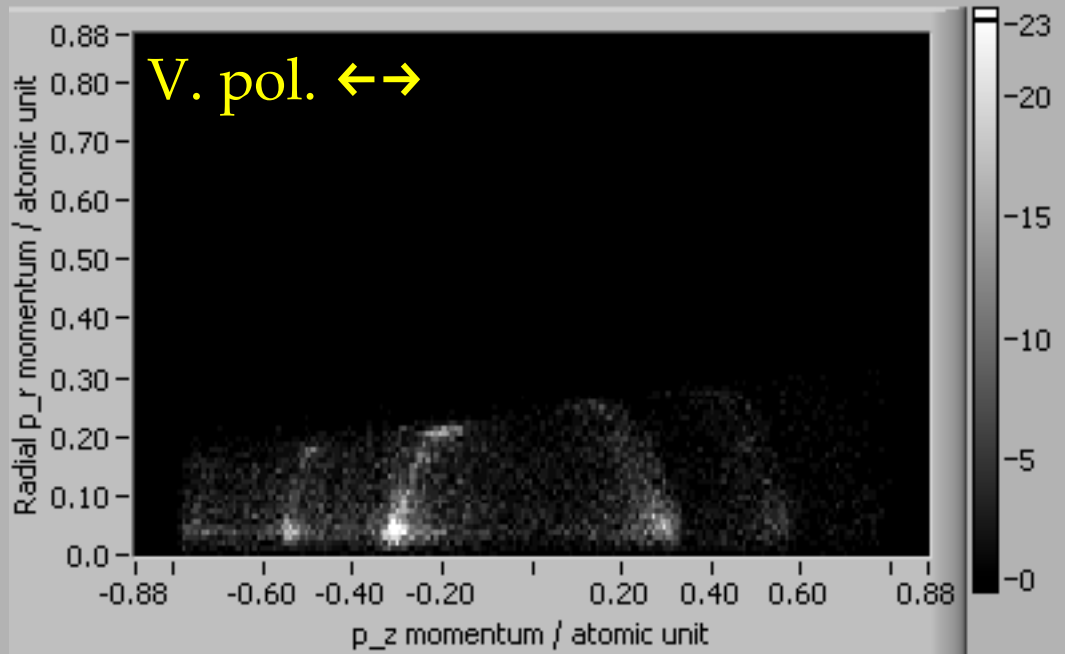
The source (focus) is extended along y-axis. Blurs the "rainbow" in y-direction.

Near-zero sideband 16 in He



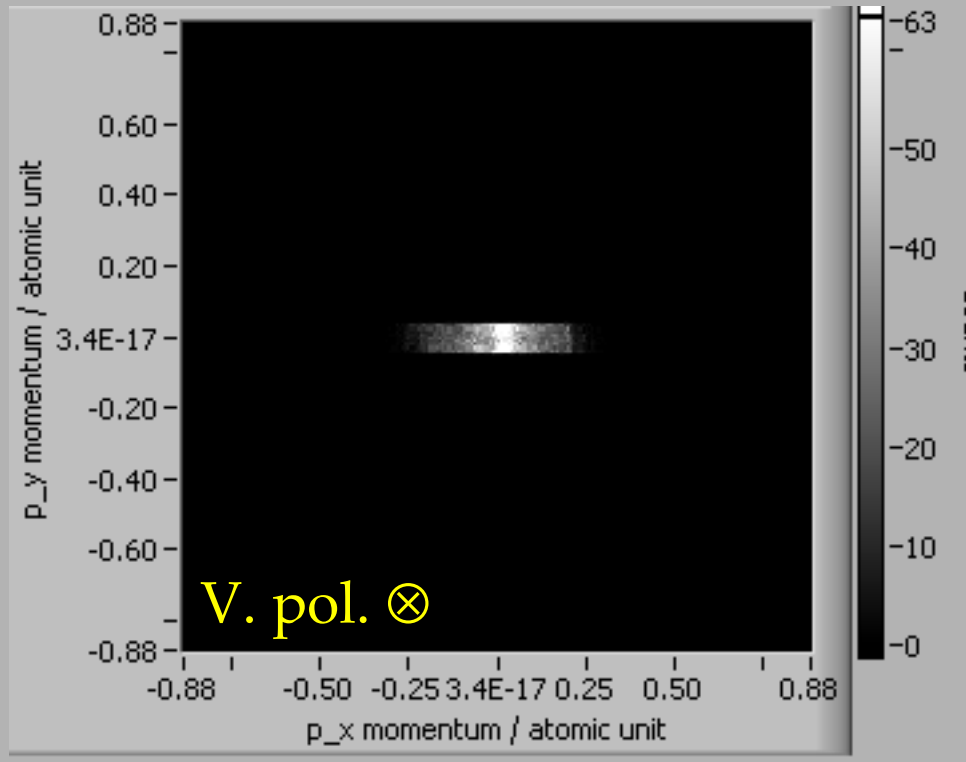


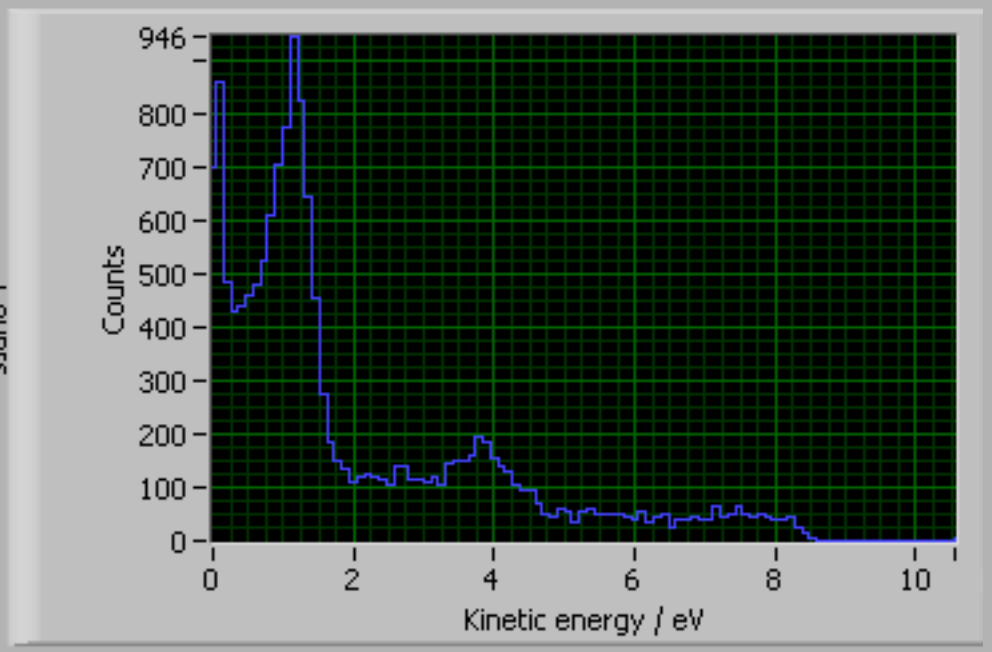
$He + h\nu_{HHG} \rightarrow He^+ + \underline{e^-}$



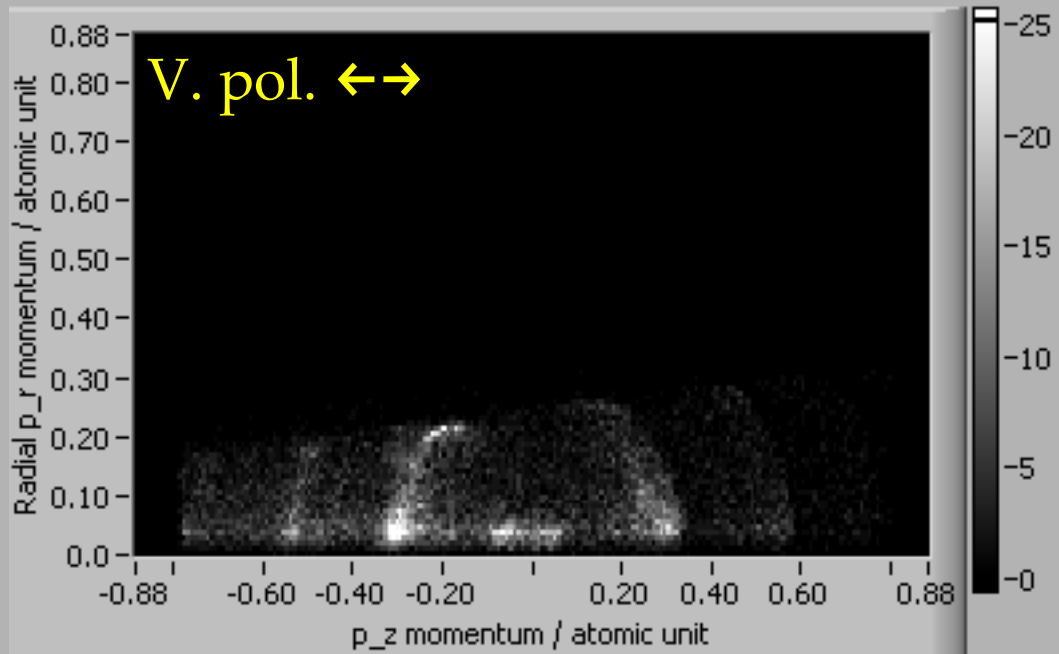
7×10^{-6} mbar He
Using 16% of 70k hits
6 minutes, 0.2 hits per shot
Only XUV

Near-zero sideband 16 in He





$He + h\nu_{HHG}\ h\nu_{IR} \rightarrow He^+ + e^-$



7×10^{-6} mbar He

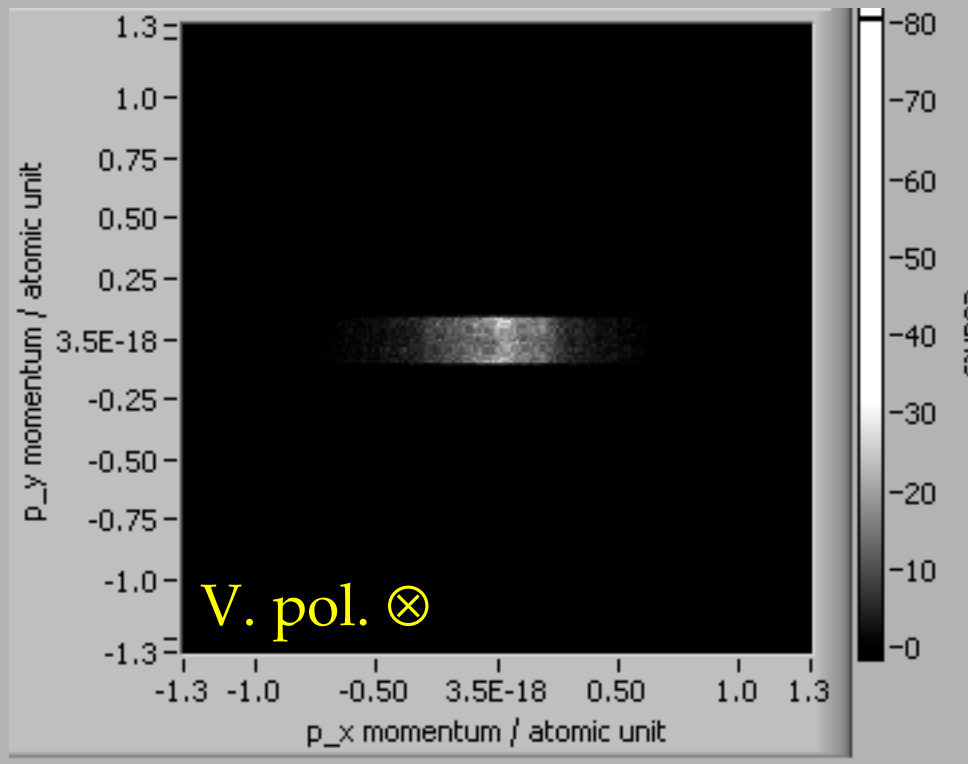
Using 17% of 90k hits

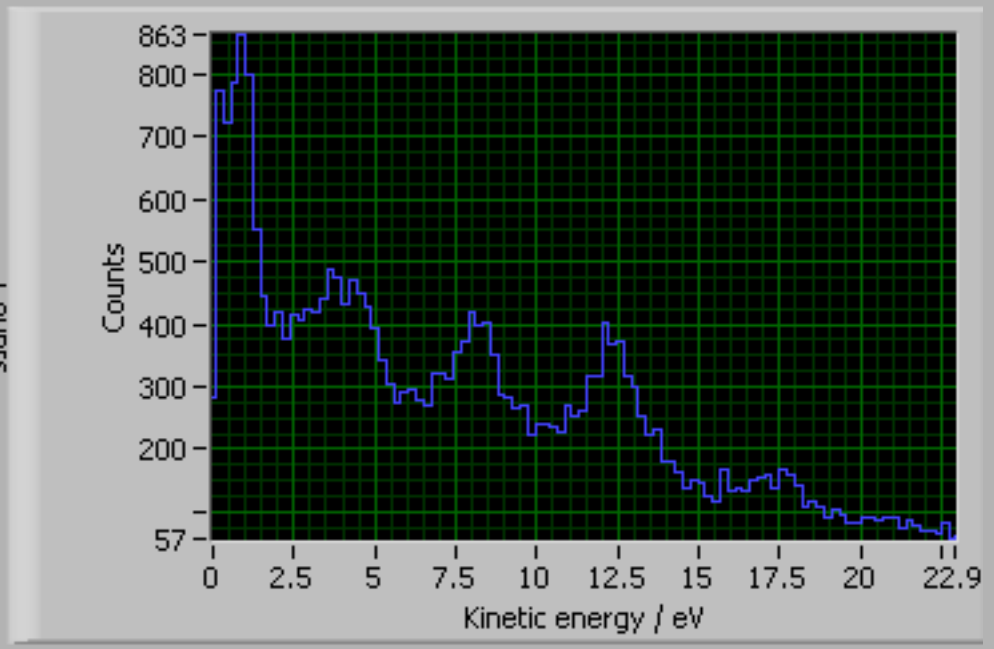
10 minutes, 0.15 hits per shot

XUV + IR probe

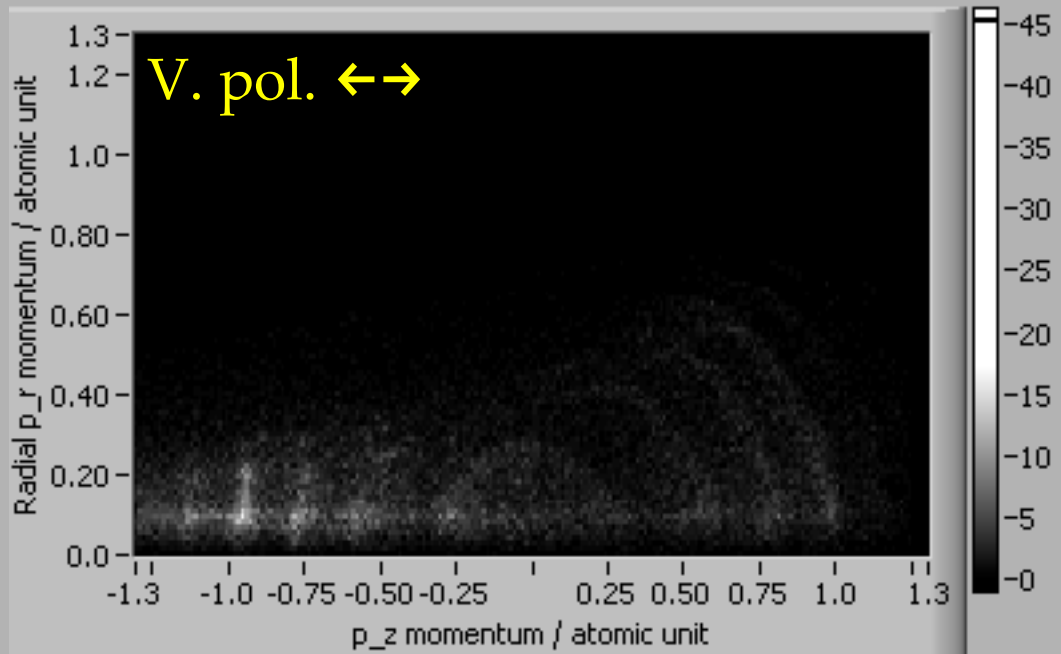
(probe alone gives 0.005 hits/shot)

Harmonics in Argon





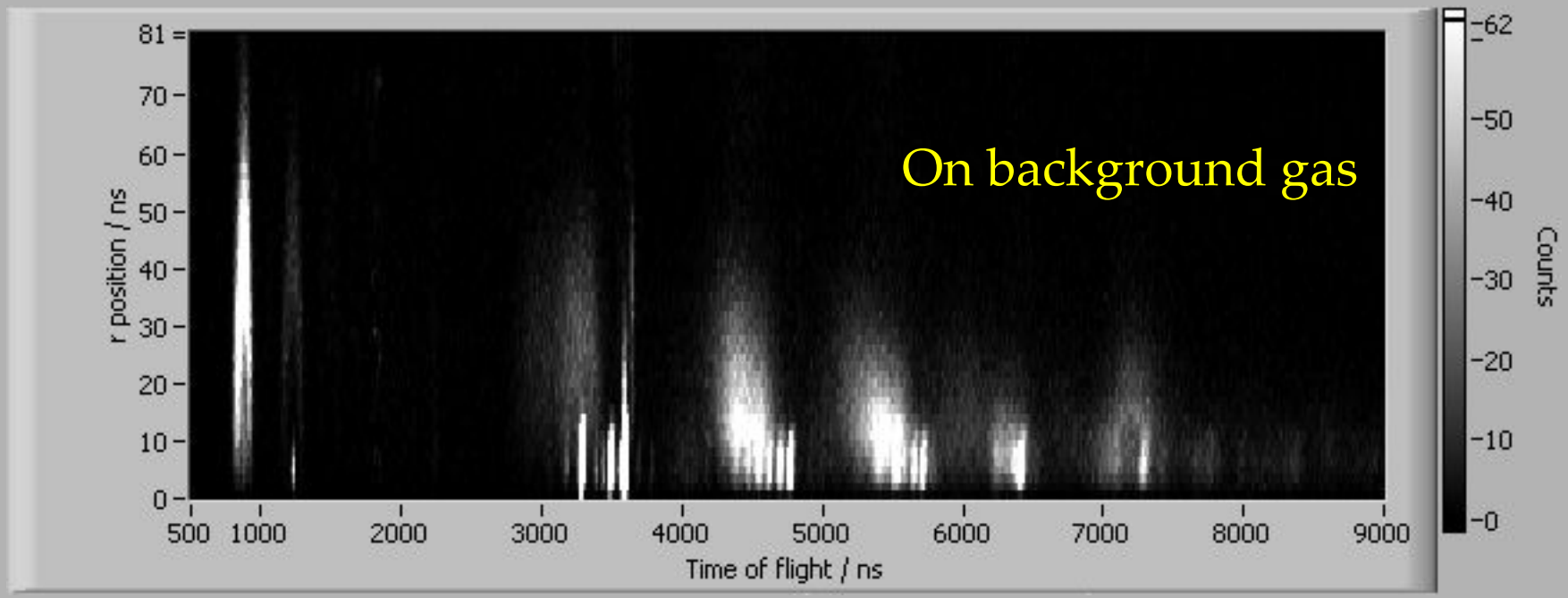
$Ar + h\nu_{HHG} \rightarrow Ar^+ + \underline{e^-}$



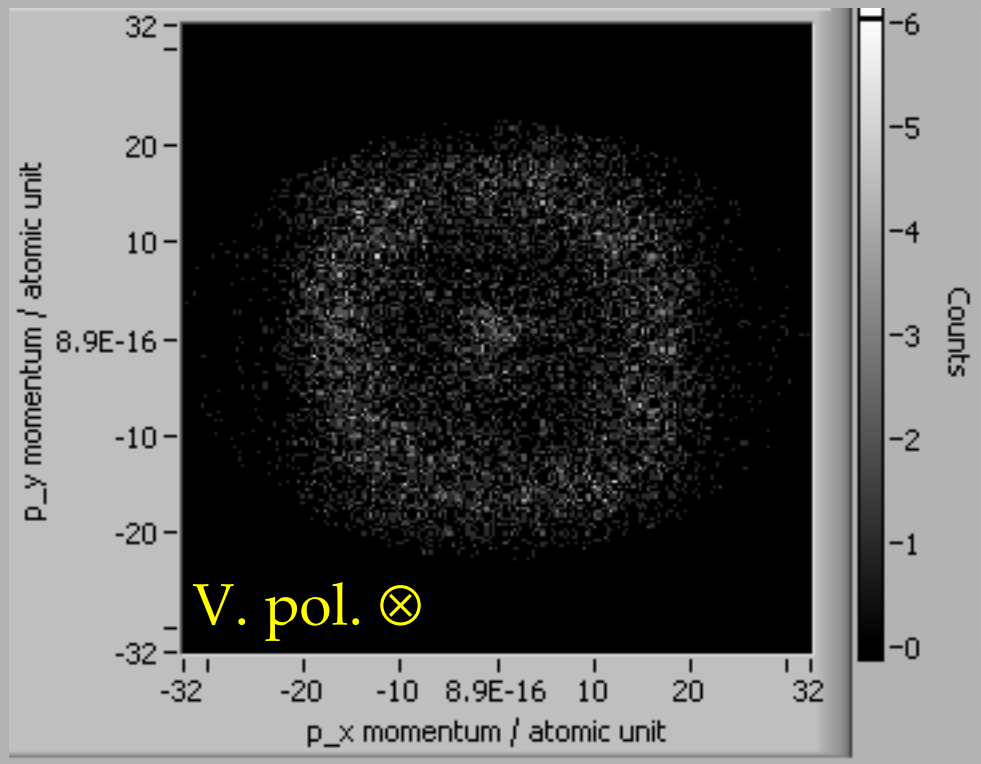
6×10^{-6} mbar Ar
Using 10% of 257k hits
11 minutes, 0.38 hits per shot.

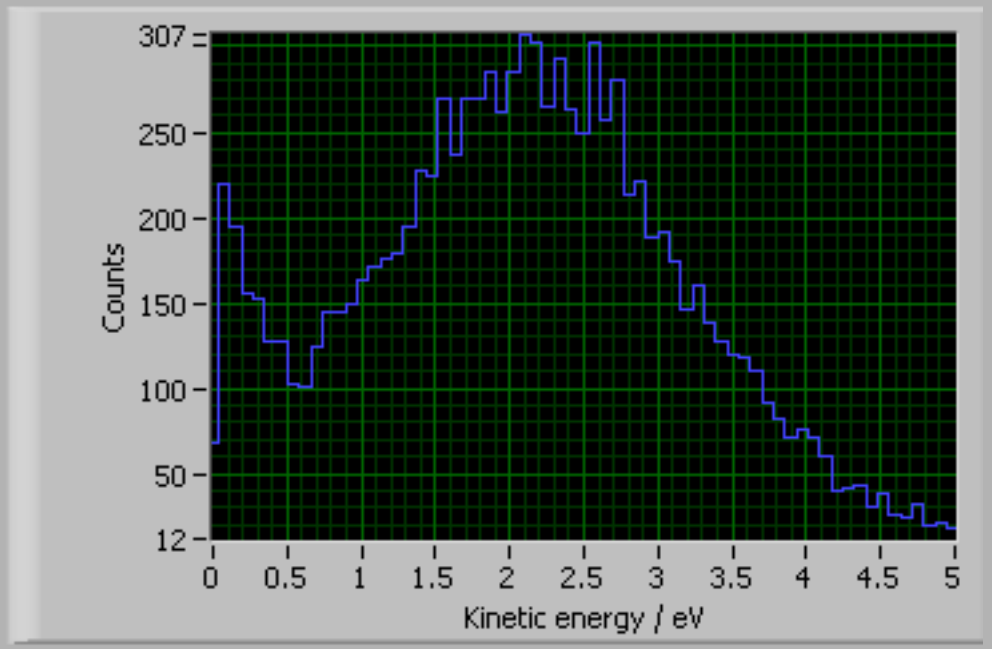
Can also detect ions

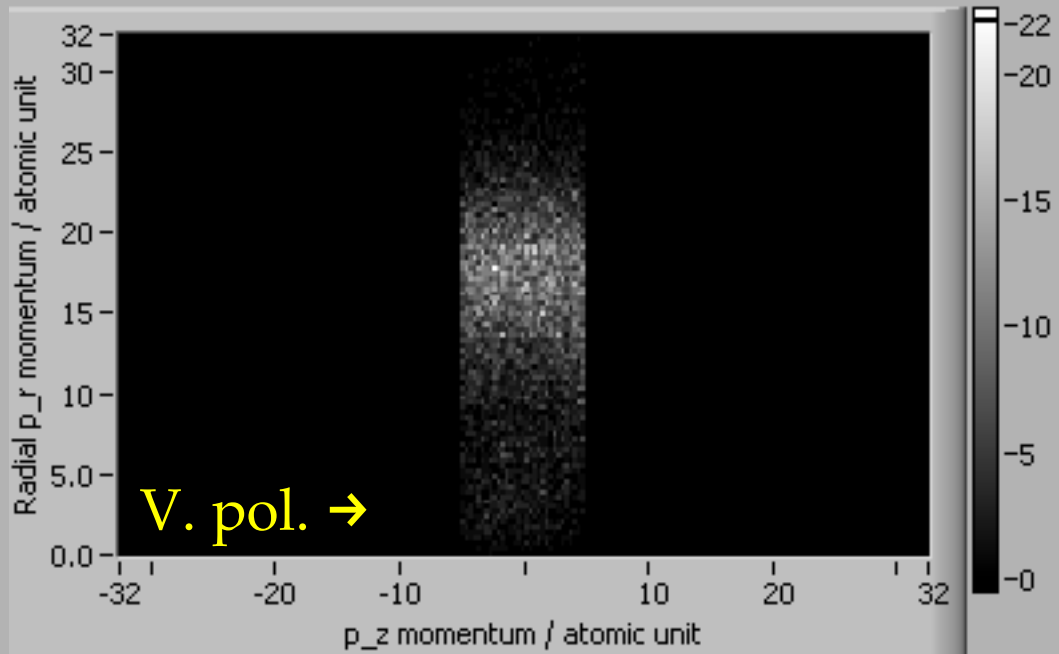
- Positive ions
  - Change sign of electrodes
- Larger mass
  - Longer time-of flight



Hydrogen ions



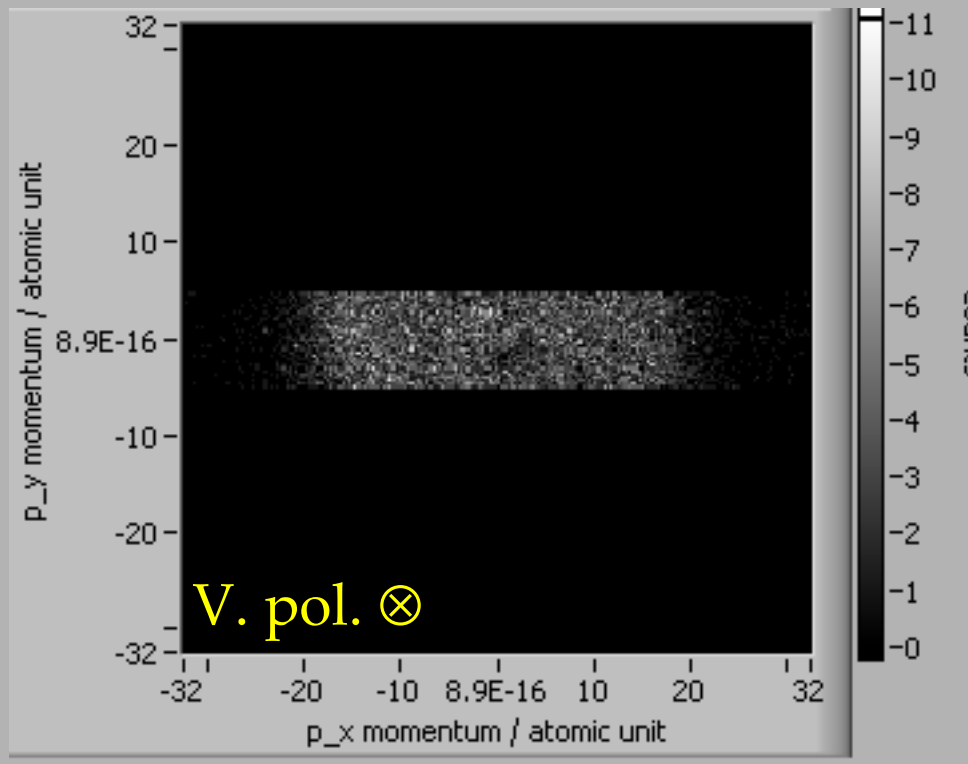


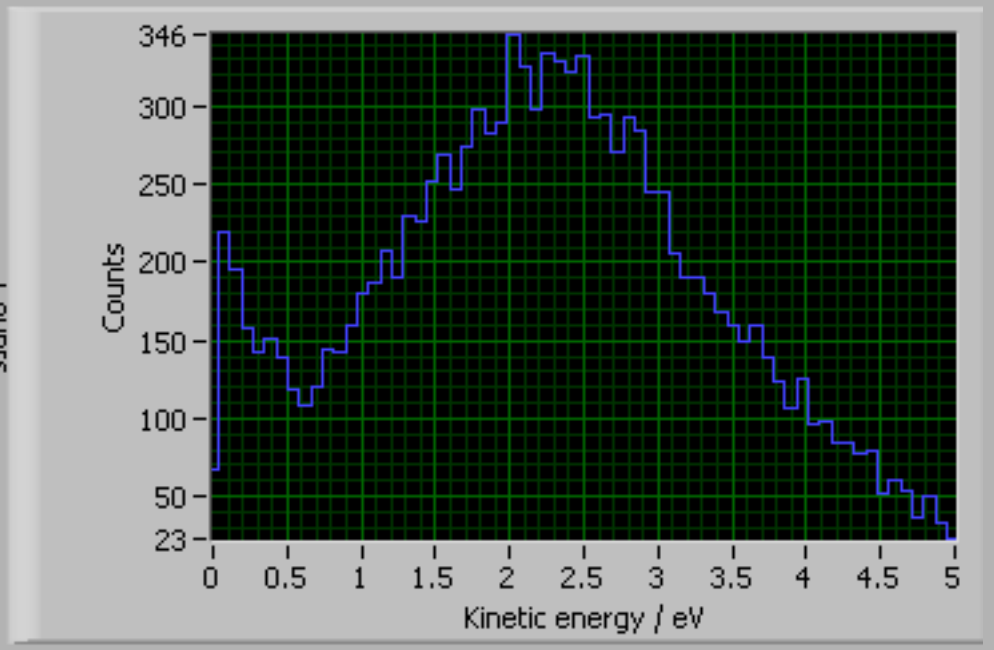


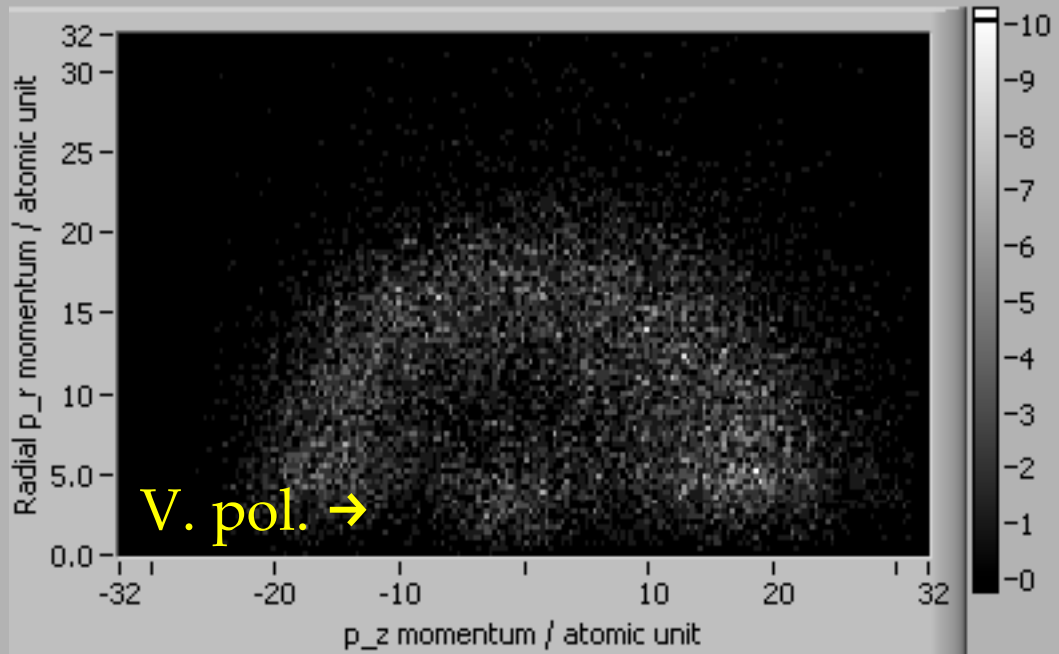
$RH + n \cdot h\nu_{IR} \rightarrow R + \underline{H^+} + e^-$

On background gas
14:20 minutes, 0.05 hits/shot
For H+: used 2.6% of 424k hits
Filter on $|P_z| < 5$

Potitive ions





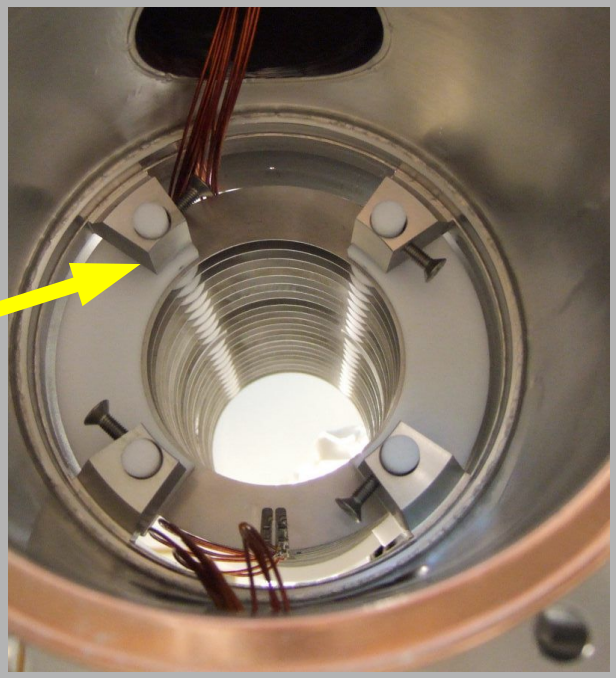


$RH + n \cdot h\nu_{IR} \rightarrow R + \underline{H^+} + e^-$

On background gas
14:20 minutes, 0.05 hits/shot
For H+: used 2.6% of 424k hits
Filter on $|P_r| < 5$

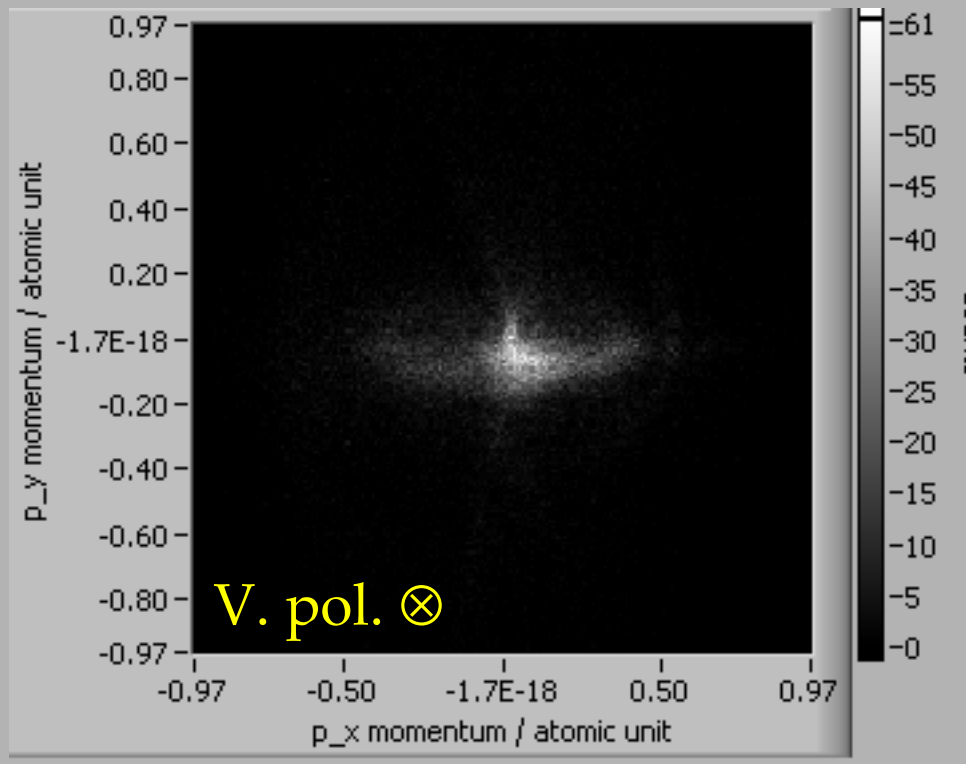
Outlooks

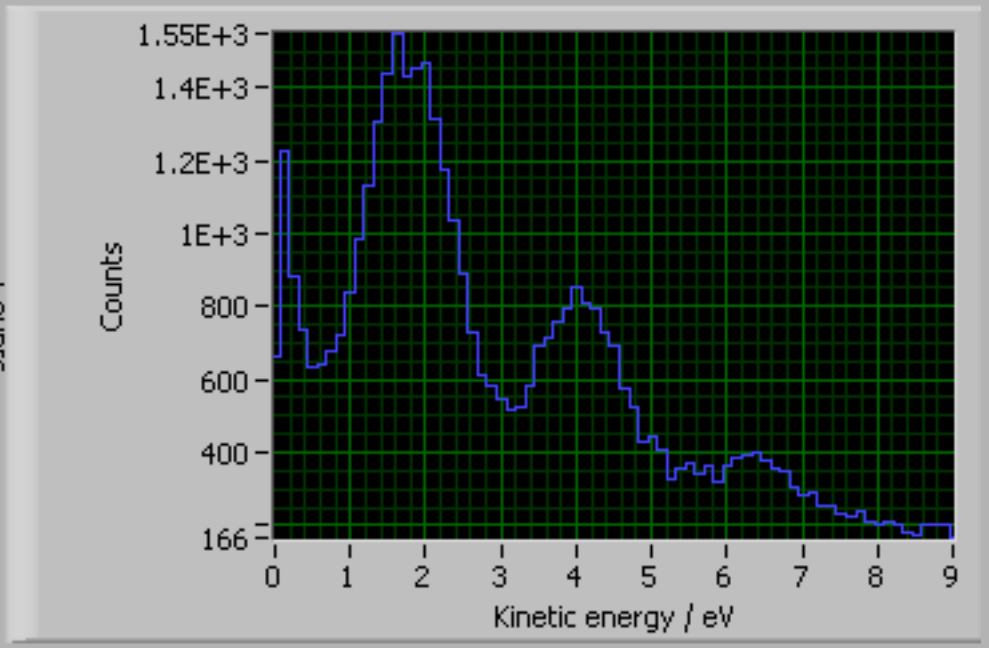
- Improve field homogenity
  - meshes
  - shield the poles
- Gas jet to reduce source volume
- Some physics :-)

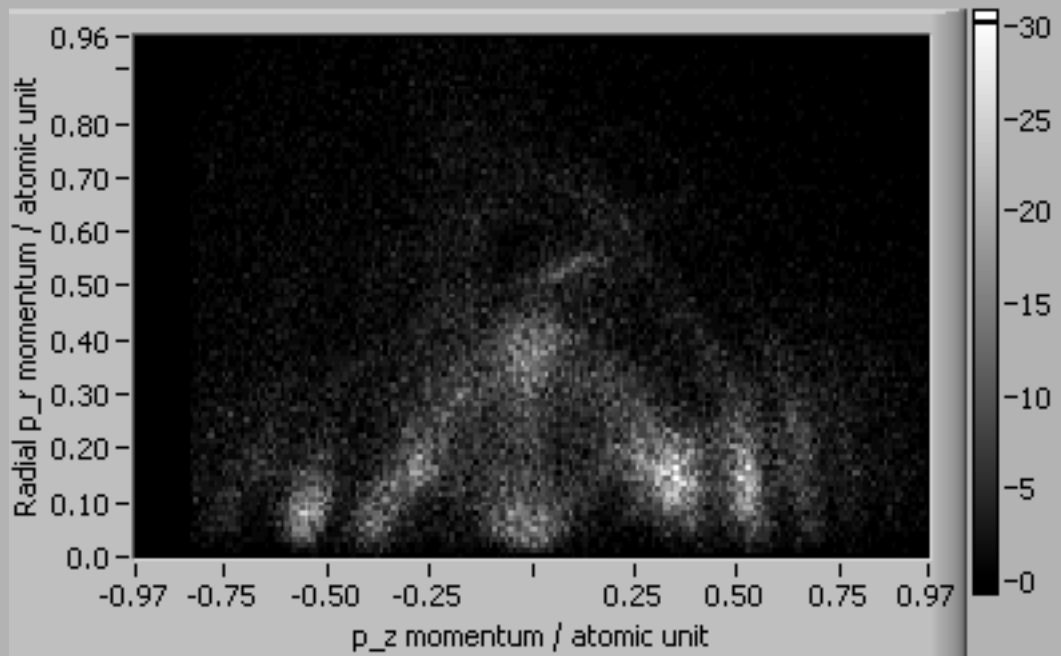


- More detectors...
  - Coincidence: electron + ion

?

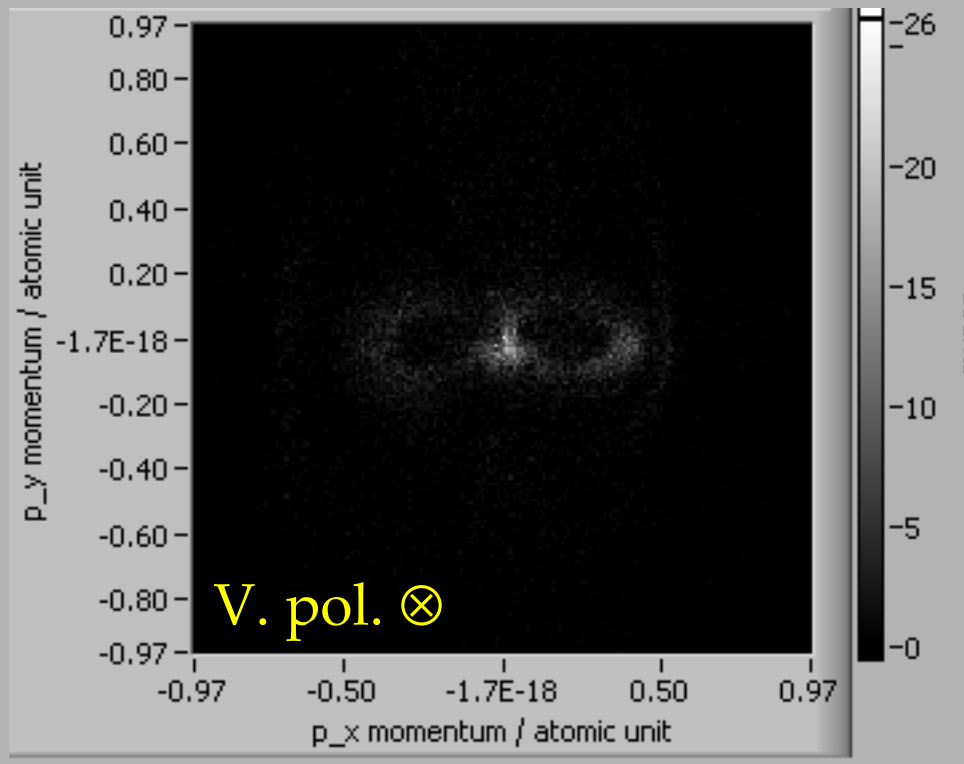

0.97
0.80
0.60
0.40
0.20
-1.7E-18
-0.20
-0.40
-0.60
-0.80
-0.97
p_y momentum / atomic unit
V. pol. ⊗
-0.97
-0.50
-1.7E-18
0.50
0.97
p_x momentum / atomic unit
=61
-55
-50
-45
-40
-35
-30
-25
-20
-15
-10
-5
-0
Counts

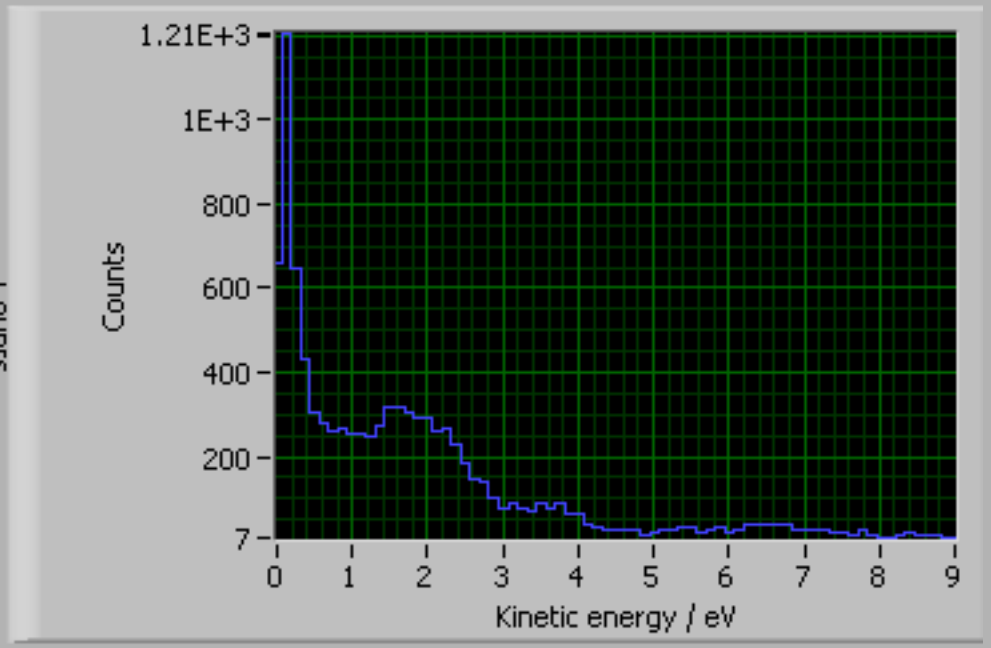

1.55E+3
1.4E+3
1.2E+3
1E+3
800
600
400
166
Counts
0
1
2
3
4
5
6
7
8
9
Kinetic energy / eV

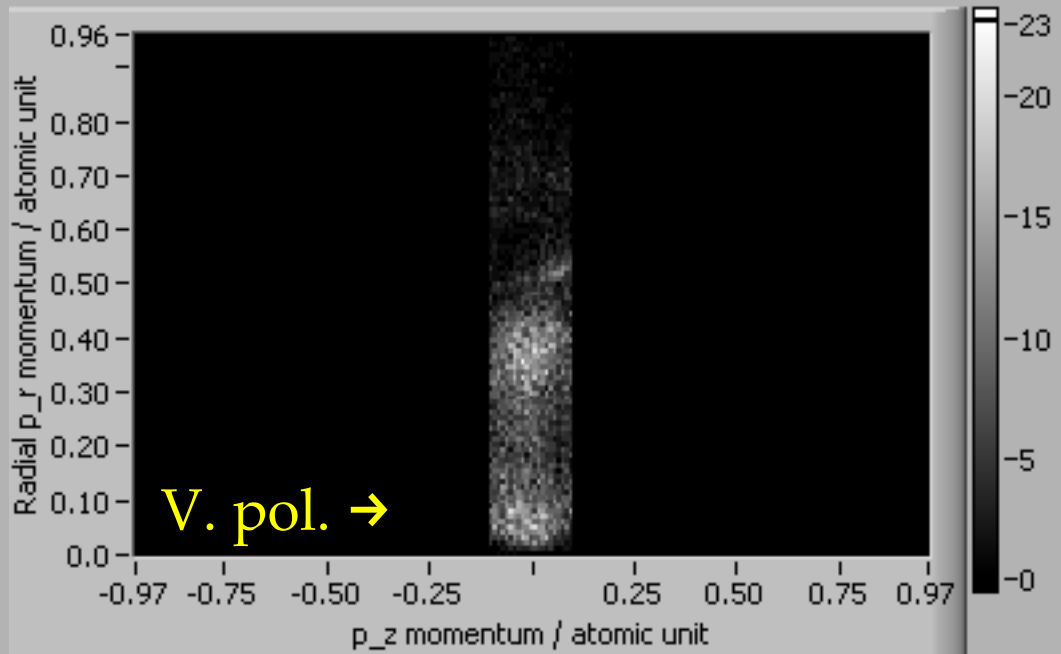

0.96
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.0
Radial p_r momentum / atomic unit
-0.97
-0.75
-0.50
-0.25
0.25
0.50
0.75
0.97
p_z momentum / atomic unit
-30
-25
-20
-15
-10
-5
-0

V. pol. →

?


0.97
0.80
0.60
0.40
0.20
-1.7E-18
-0.20
-0.40
-0.60
-0.80
-0.97
p_y momentum / atomic unit
V. pol. ⊗
-0.97
-0.50
-1.7E-18
0.50
0.97
p_x momentum / atomic unit
-26
-20
-15
-10
-5
-0


1.21E+3
1E+3
800
600
400
200
7
Counts
Counts
0
1
2
3
4
5
6
7
8
9
Kinetic energy / eV


0.96
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.0
Radial p_r momentum / atomic unit
V. pol. →
-0.97
-0.75
-0.50
-0.25
0.25
0.50
0.75
0.97
p_z momentum / atomic unit
-23
-20
-15
-10
-5
-0