# A Search for Right-Handed Currents in $^{37}K$ $\beta$-Decay

Melissa Anholm[1][2]

The TRINAT Collaboration:

D. Ashery[3], S. Behling[4], J.A. Behr[2], I Cohen[3], B. Fenker[4], A. Gorelov[2], G. Gwinner[1], L. Kurchaninov[2], M. Mehlman[4], D. Melconian[4], K. Olchanski[2], C. Preston[2], C. Warner[2].

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[1] University of Manitoba
[2] TRIUMF
[3] Tel Aviv University
[4] Cyclotron Institute, Texas A&M University

# The Decay Process

- Goal: Search for new physics.
  - Sensitive to right-handed currents, scalar/tensor currents, etc.

Isobaric analog decay minimizes nuclear structure corrections.

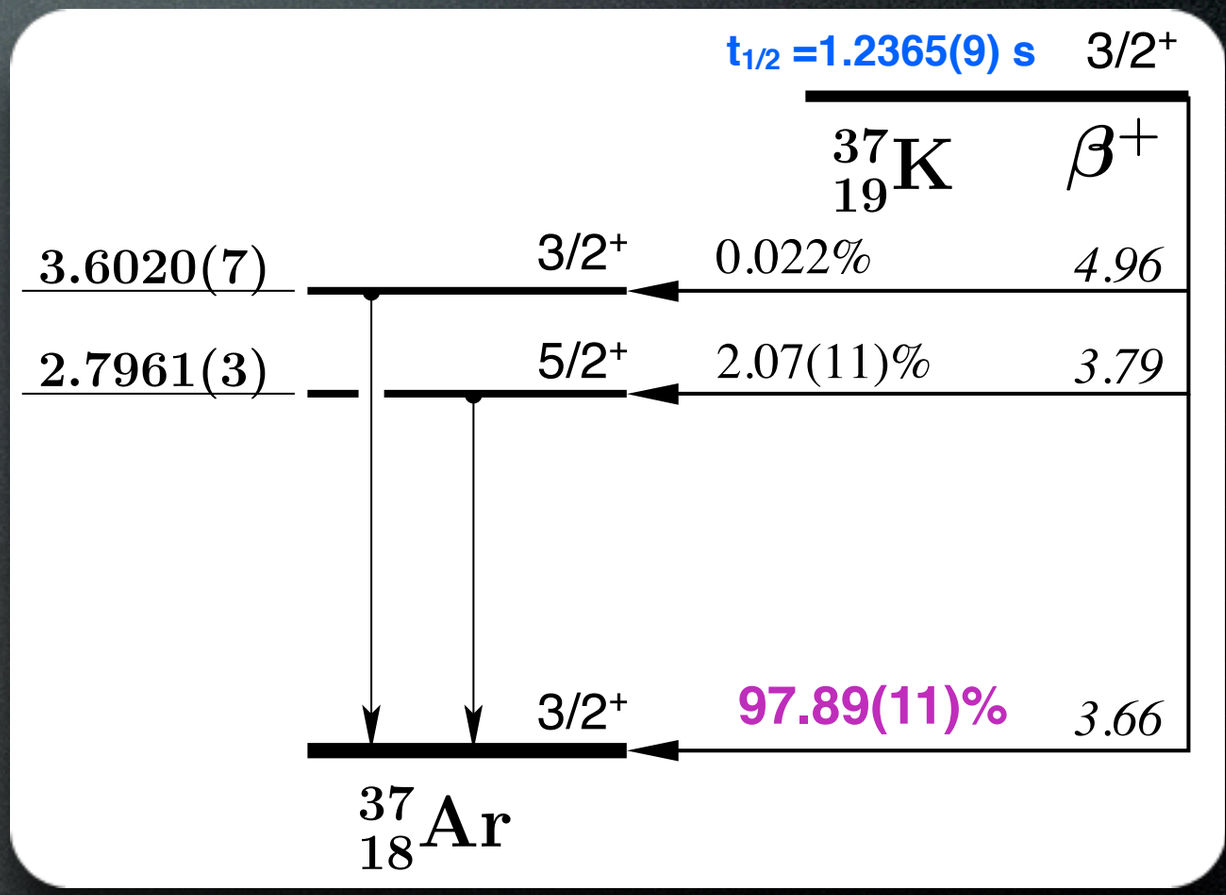



Diagram (mostly) courtesy of D. Melconian

- $^{37}K \rightarrow {}^{37}Ar + \beta^+ + \nu$
- 97.99(14)% branch:
  - $(I^\pi = 3/2^+) \rightarrow (I^\pi = 3/2^+)$
  - $G_A M_{GT} / G_V M_F = 0.560^{+24}_{-29}$ [1]



[1] P. Shidling et. al, 2014

# An Observable?

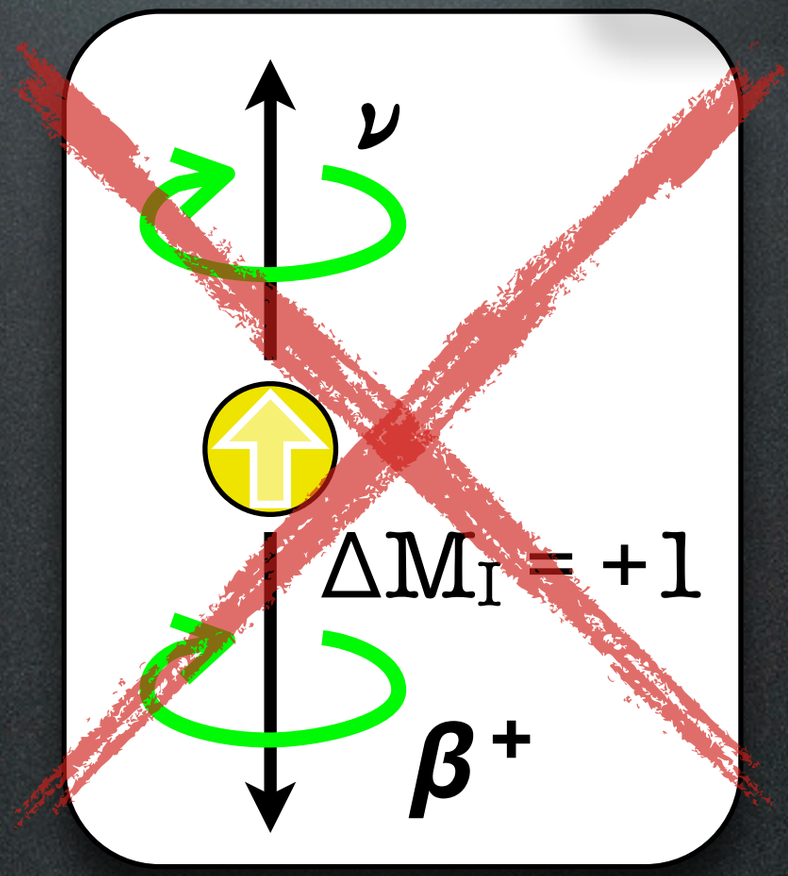
$$W(\theta_{\beta\nu}) \sim 1 + \left( \frac{a_{\beta\nu} + \langle P \rangle B_\nu - \frac{2}{3} T c_{\text{align}}}{1 + \langle P \rangle A_\beta + \frac{m}{E} b_{\text{Fierz}}} \right) \cos\theta_{\beta\nu}$$

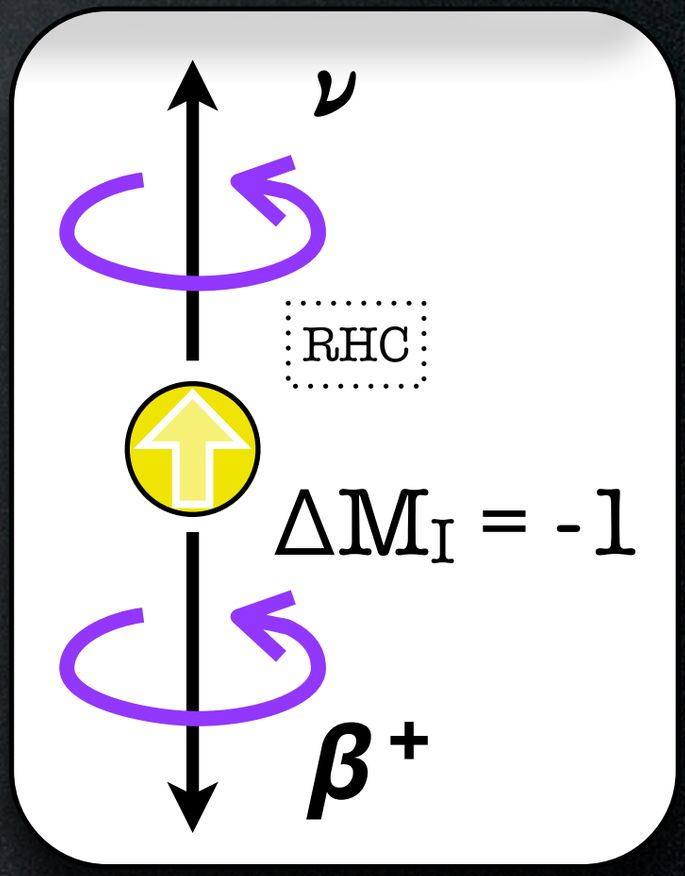
$$T \equiv \frac{I(I+1) - 3\langle (\vec{I} \cdot \hat{I})^2 \rangle}{I(2I-1)}$$

$$\langle P \rangle \equiv \frac{\langle I \rangle}{I}$$

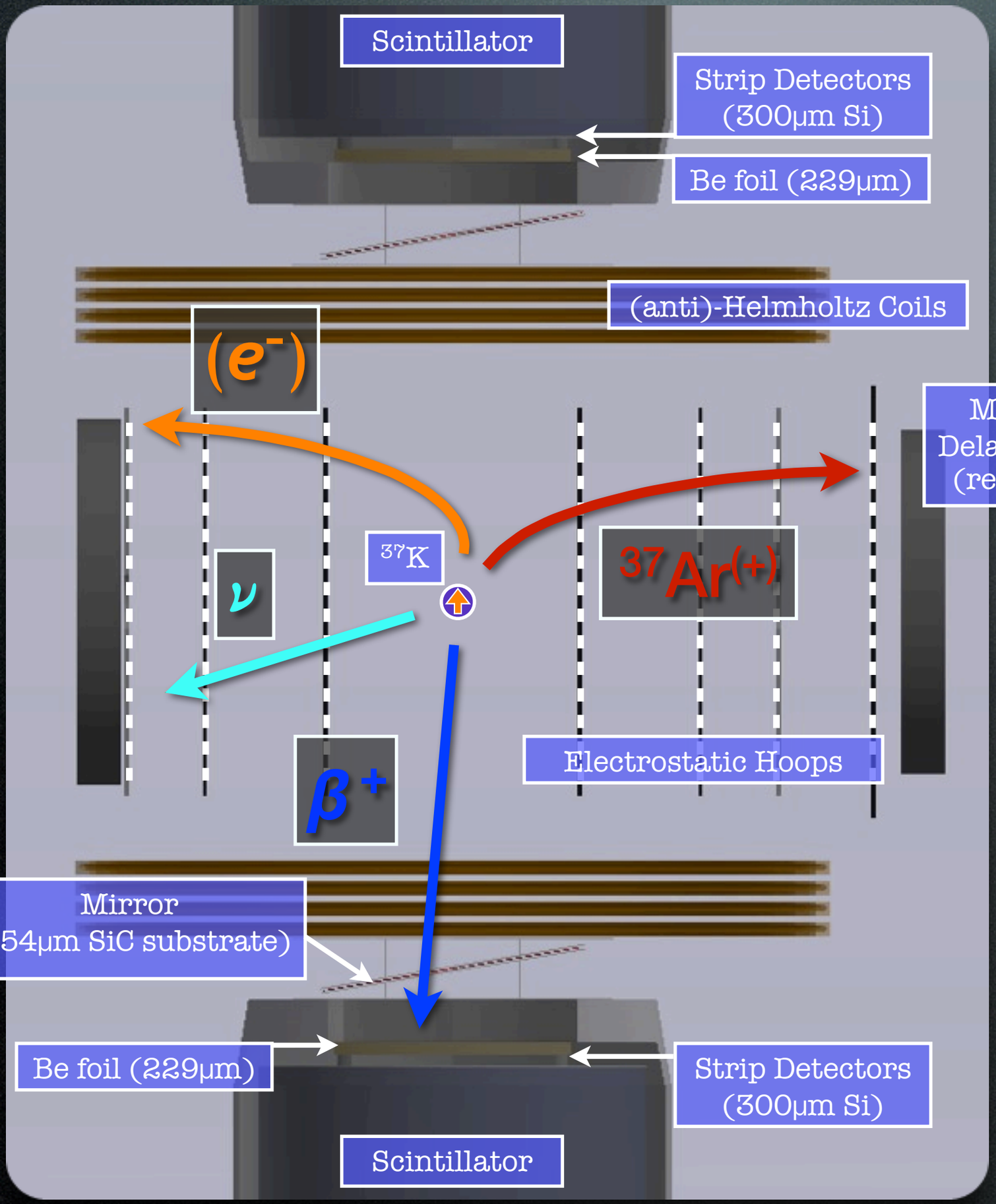
In our geometry, the β momentum is very nearly parallel or antiparallel to the polarization direction.

$^{37}K \rightarrow {}^{37}Ar + \beta^+ + \nu$

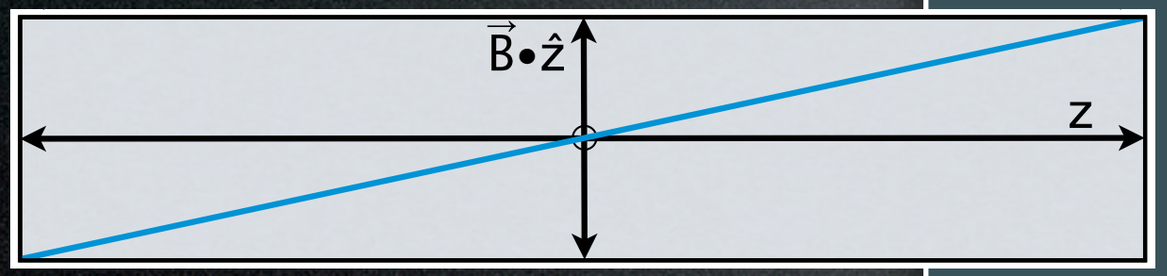


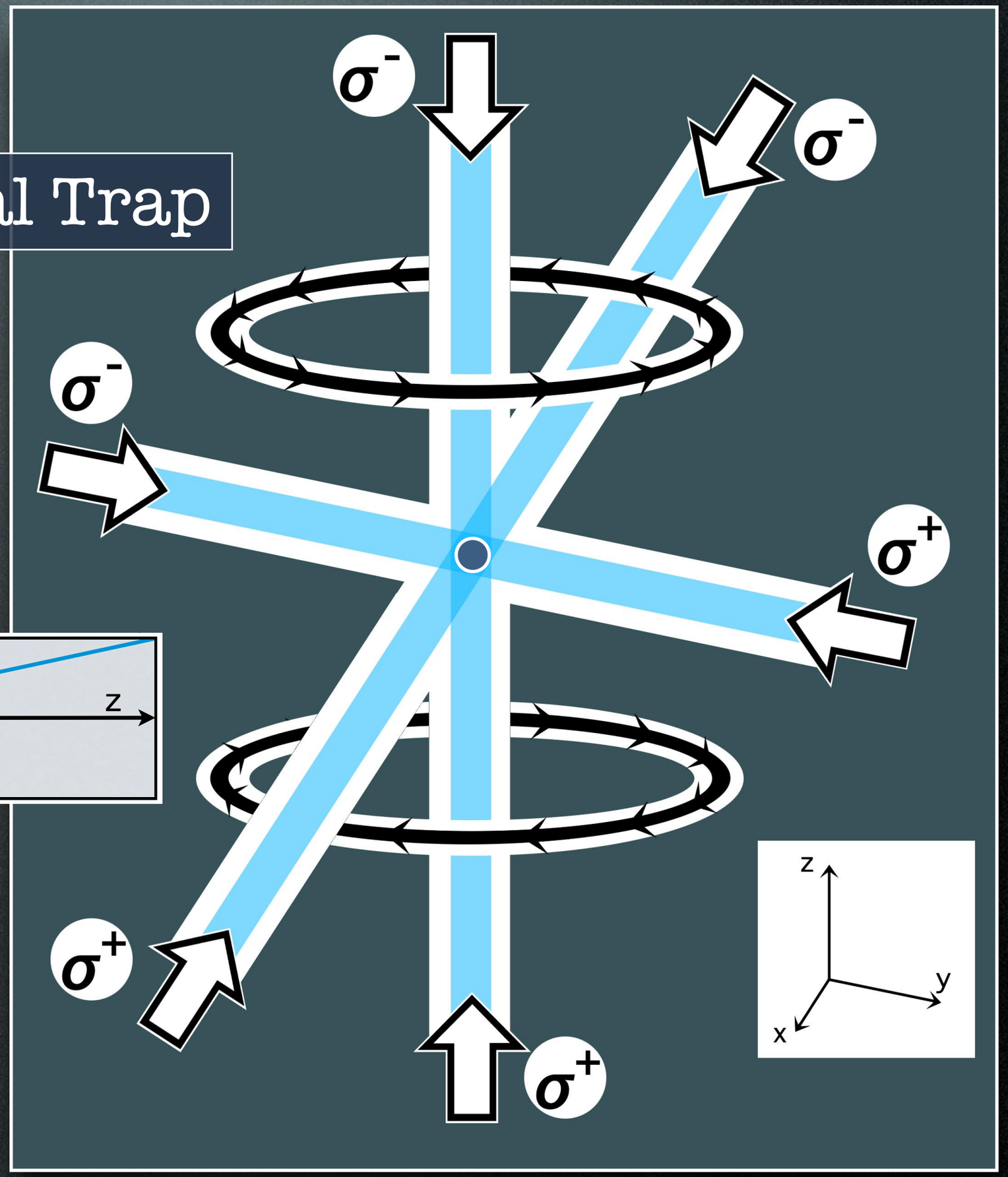



# A Decay Event



# A Magneto-Optical Trap



# Polarization

β Detector

Mirror
(254μm SiC substrate)

Optical Pumping
Light

$^{37}K^{+}$ Photoions

MCP +
Delay Line
(recoils)

19°

Mirror
(254μm SiC substrate)

β Detector

Polarization Achieved: [1][2]
$\langle I \rangle / I = \{+0.992(1), -0.992(1)\}$

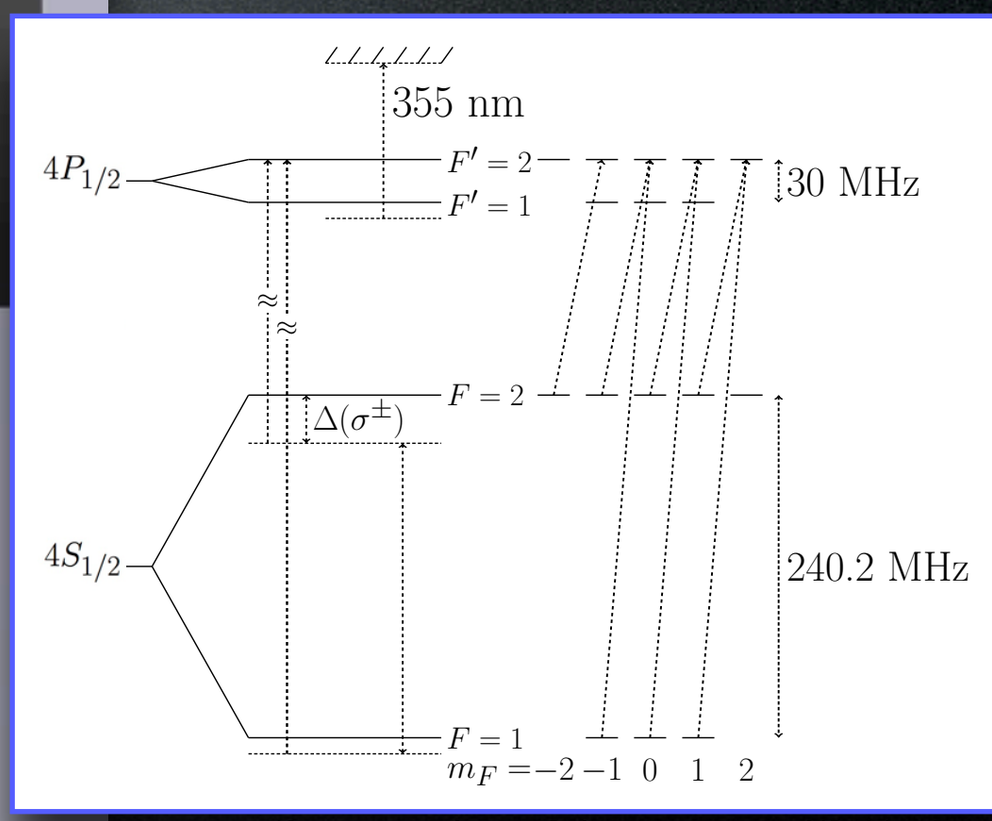


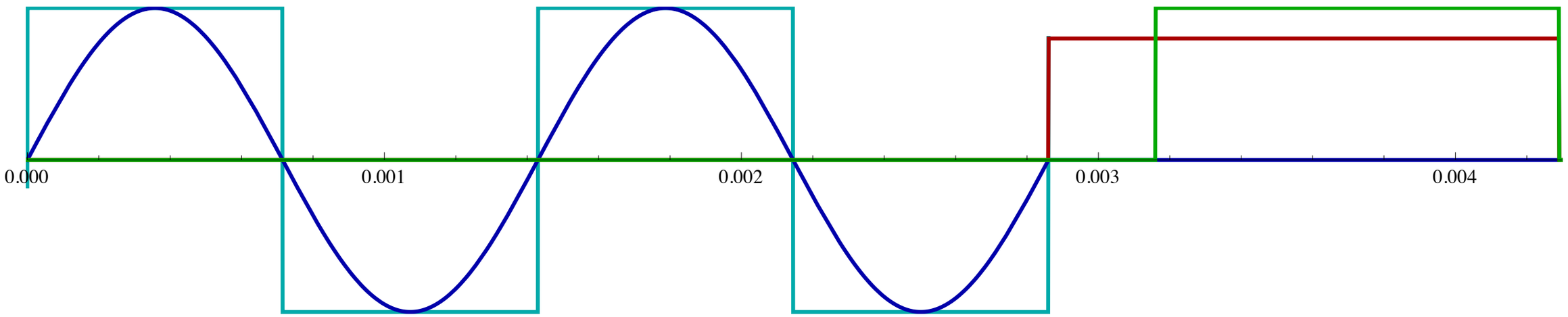

Diagram (mostly) courtesy of B. Fenker.


[1] B. Fenker et. al., in preparation.
[2] B. Fenker., SSP 2015

# Turning off the AC-MOT

**Magnetic (quadrupole) field**
**Trapping Laser Polarization**

**Magnetic (dipole) field**
**Optical Pumping Laser**






M. Harvey and A. J. Murray, Phys. Rev. Lett. 101, 173201 (2008)

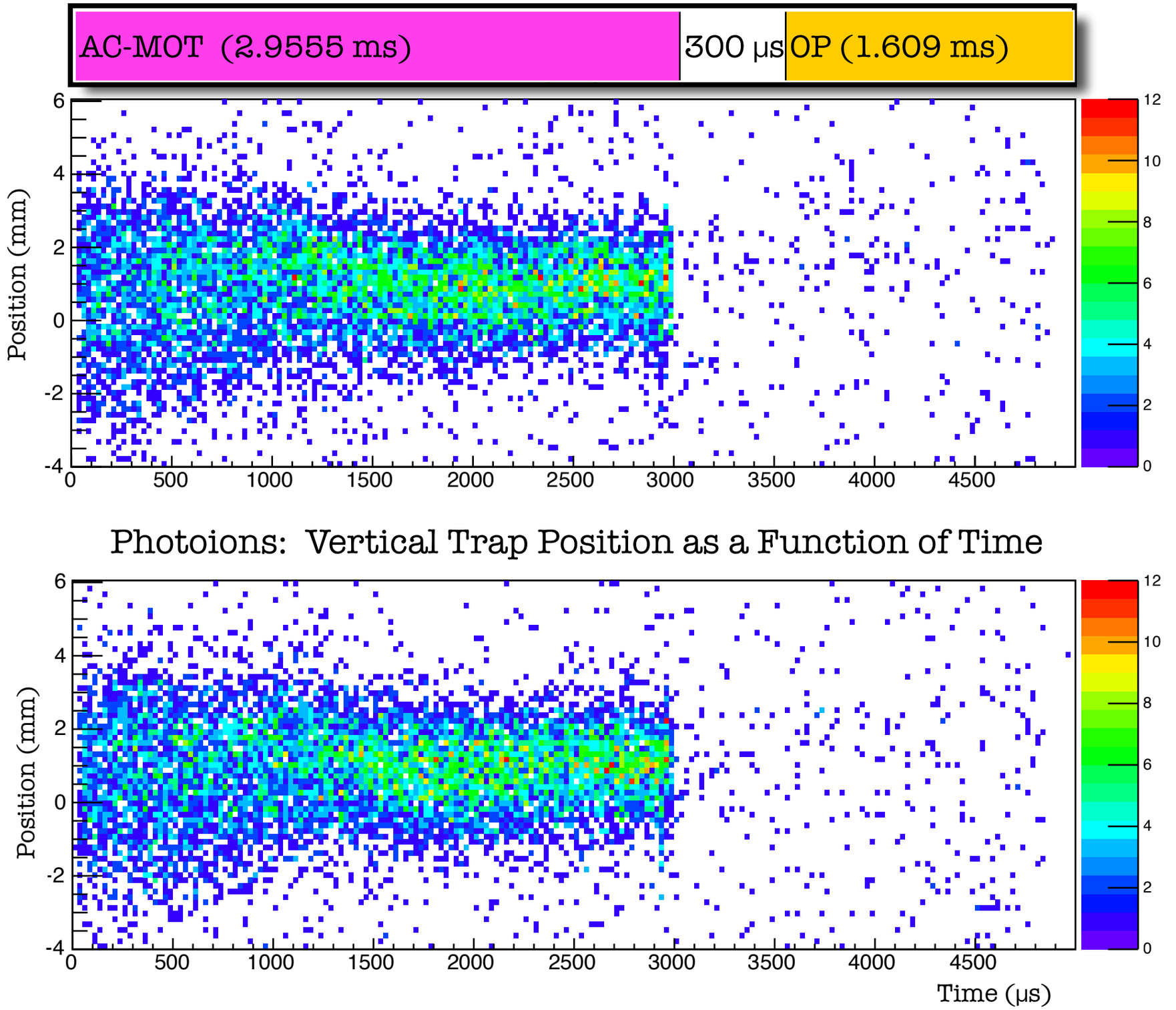
# Polarization Flips

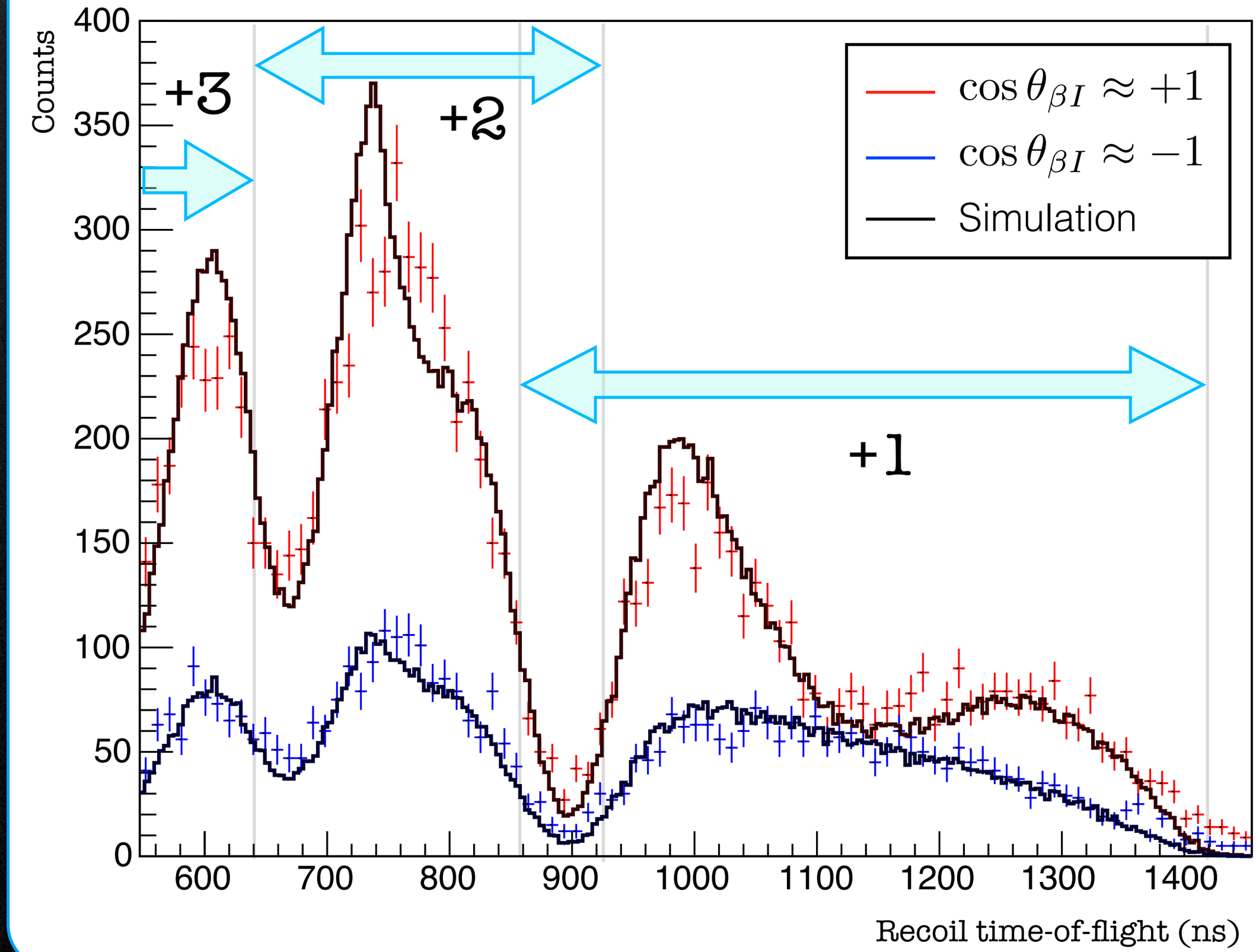
Polarization State 1:

Centroid: 0.906 ± 0.013 mm
Width: 1.255 ± 0.012 mm

Polarization State 2:

Centroid: 0.908 ± 0.013 mm
Width: 1.249 ± 0.018 mm




Polarized TOF Combinations at 535 V/cm
Counts
400
350
300
250
200
150
100
50
0
+3
+2
+1
$\cos\theta_{\beta I} \approx +1$
$\cos\theta_{\beta I} \approx -1$
Simulation
600
700
800
900
1000
1100
1200
1300
1400
Recoil time-of-flight (ns)

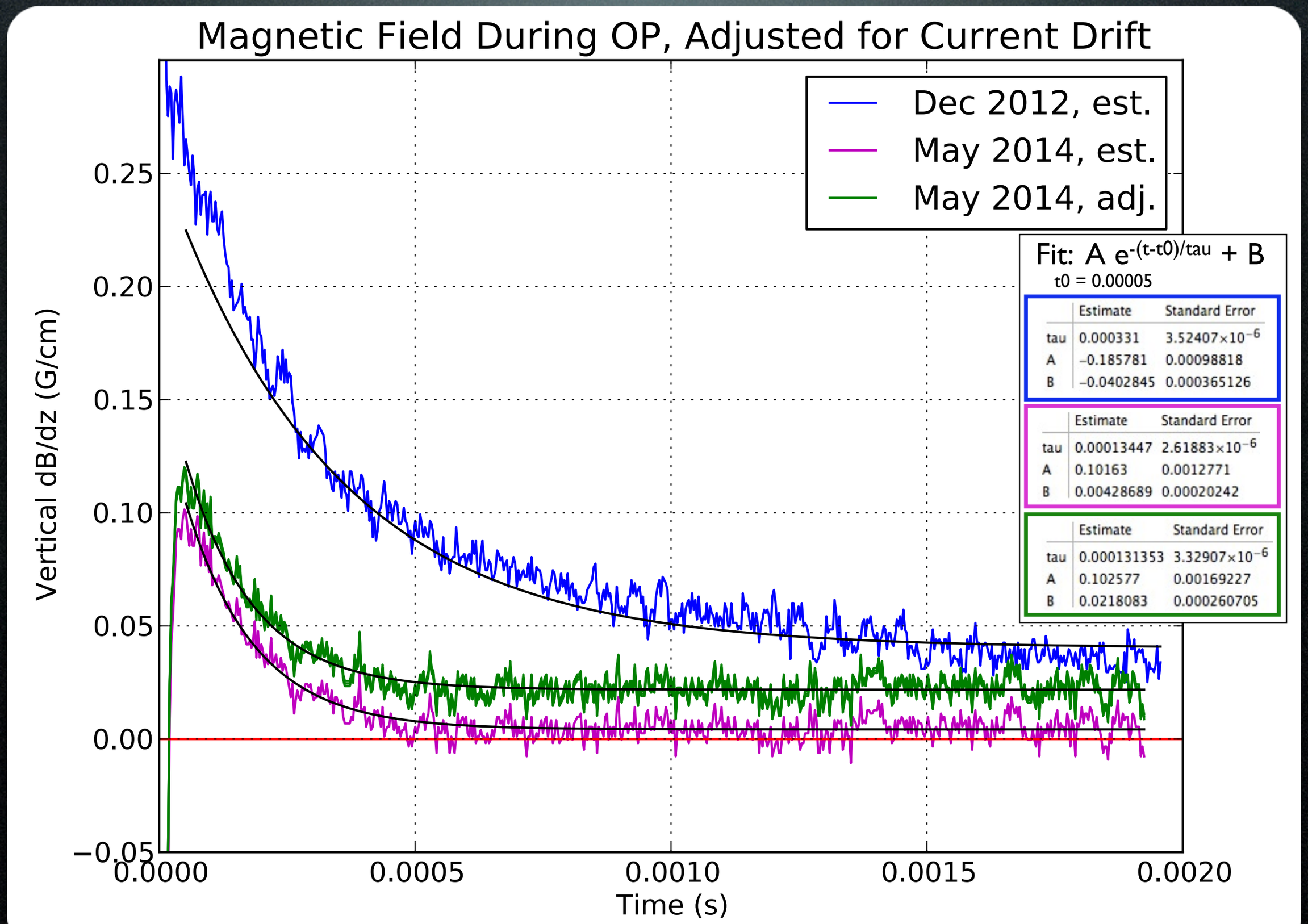
# Conclusion

- Earlier: Polarized $^{37}$K decay data has been collected at 3 different electric field values.
- Now: Data analysis is underway.
- Soon: Improved simulations with GEANT4, to include our non-uniform E-field, and BSM physics.
- Later: Fits to simulations to extract BSM parameters.

- From the Collaboration:
  - Polarization results to be published soon.[1]
  - Analysis for $A_\beta$ is also in progress.

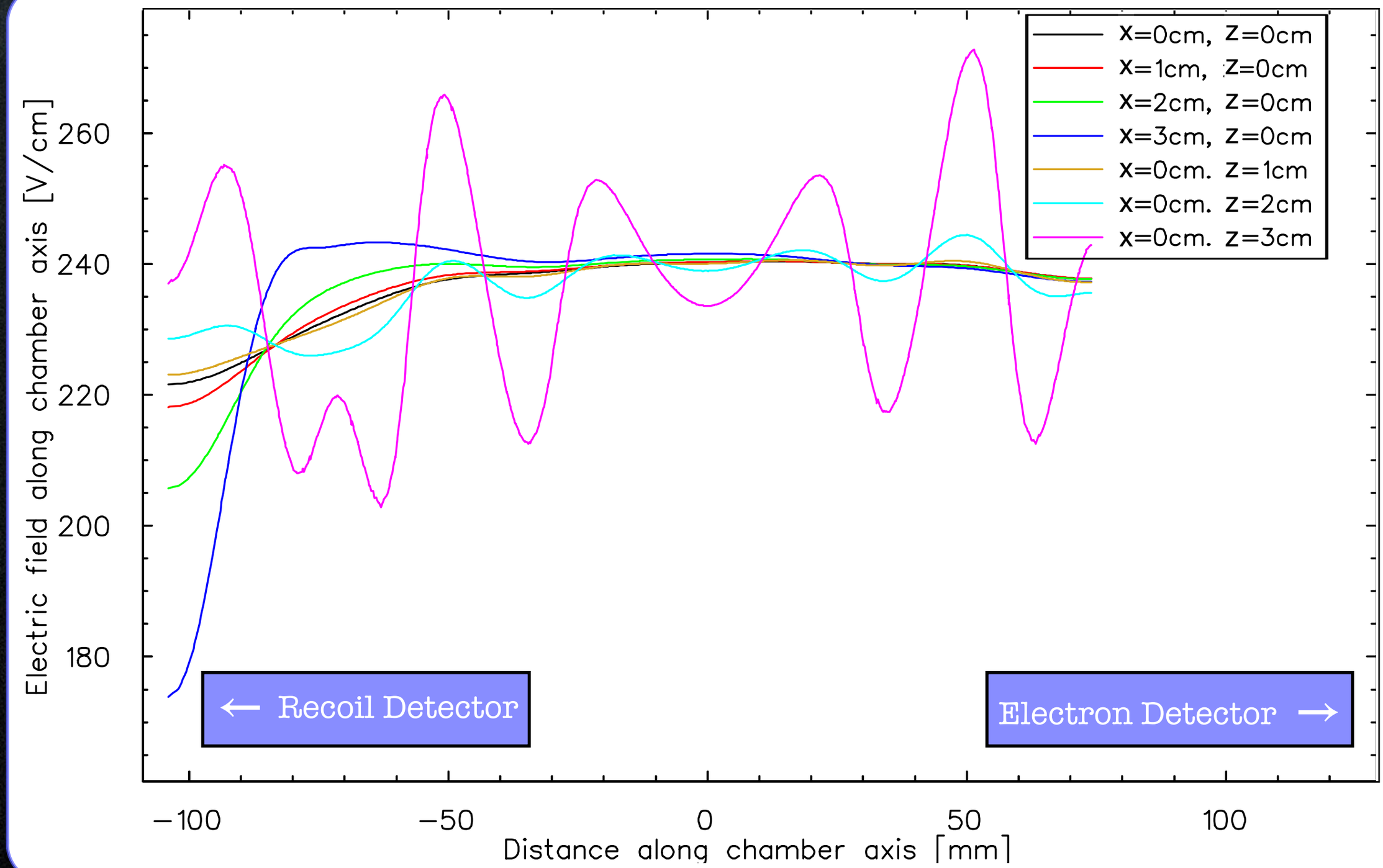


[1] B. Fenker et. al., in preparation.



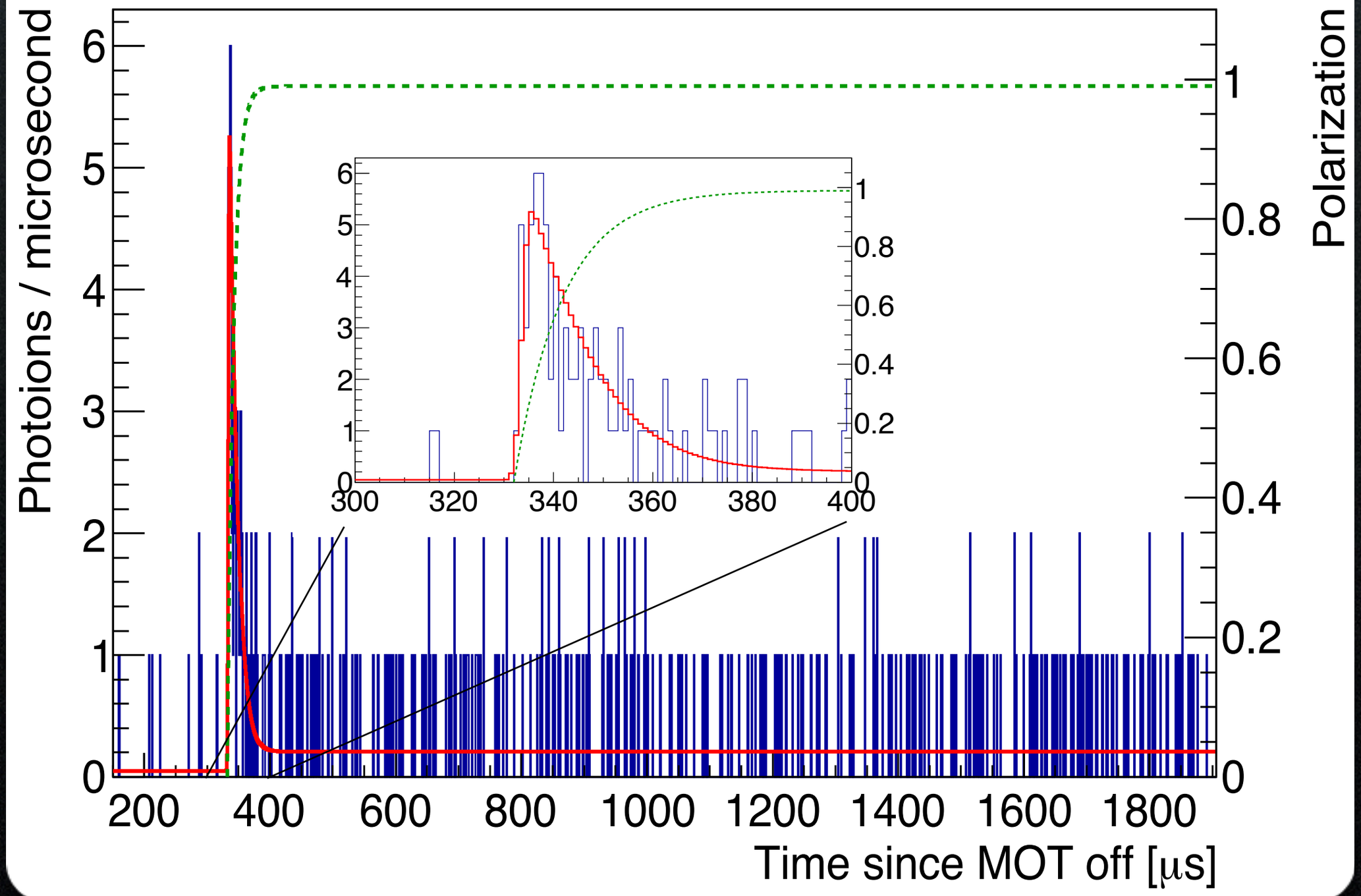

# Residual Quadrupole Field

Figure courtesy of A. Gorelov




# Electric Field in the Chamber

# Polarization Diagnostics

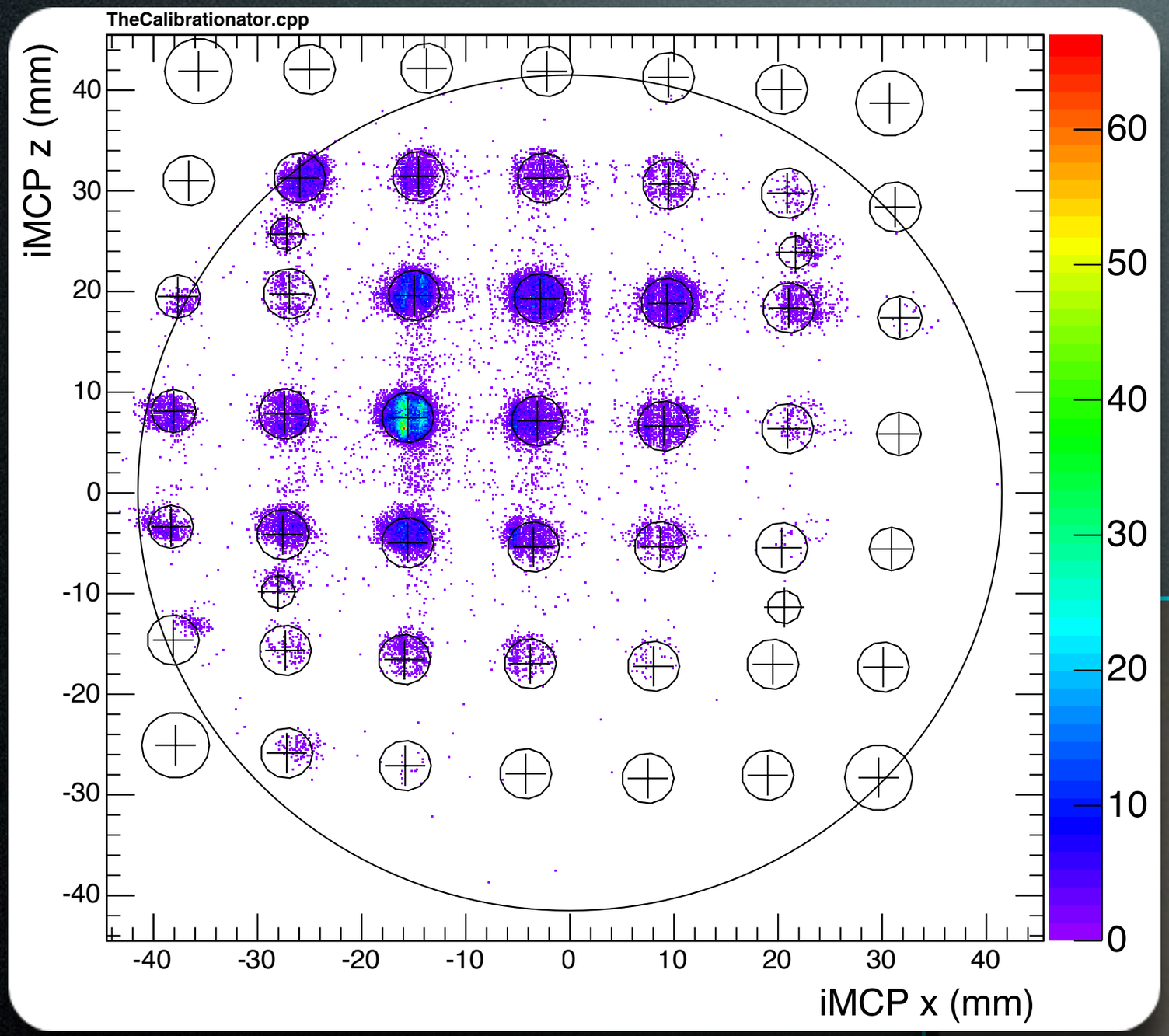


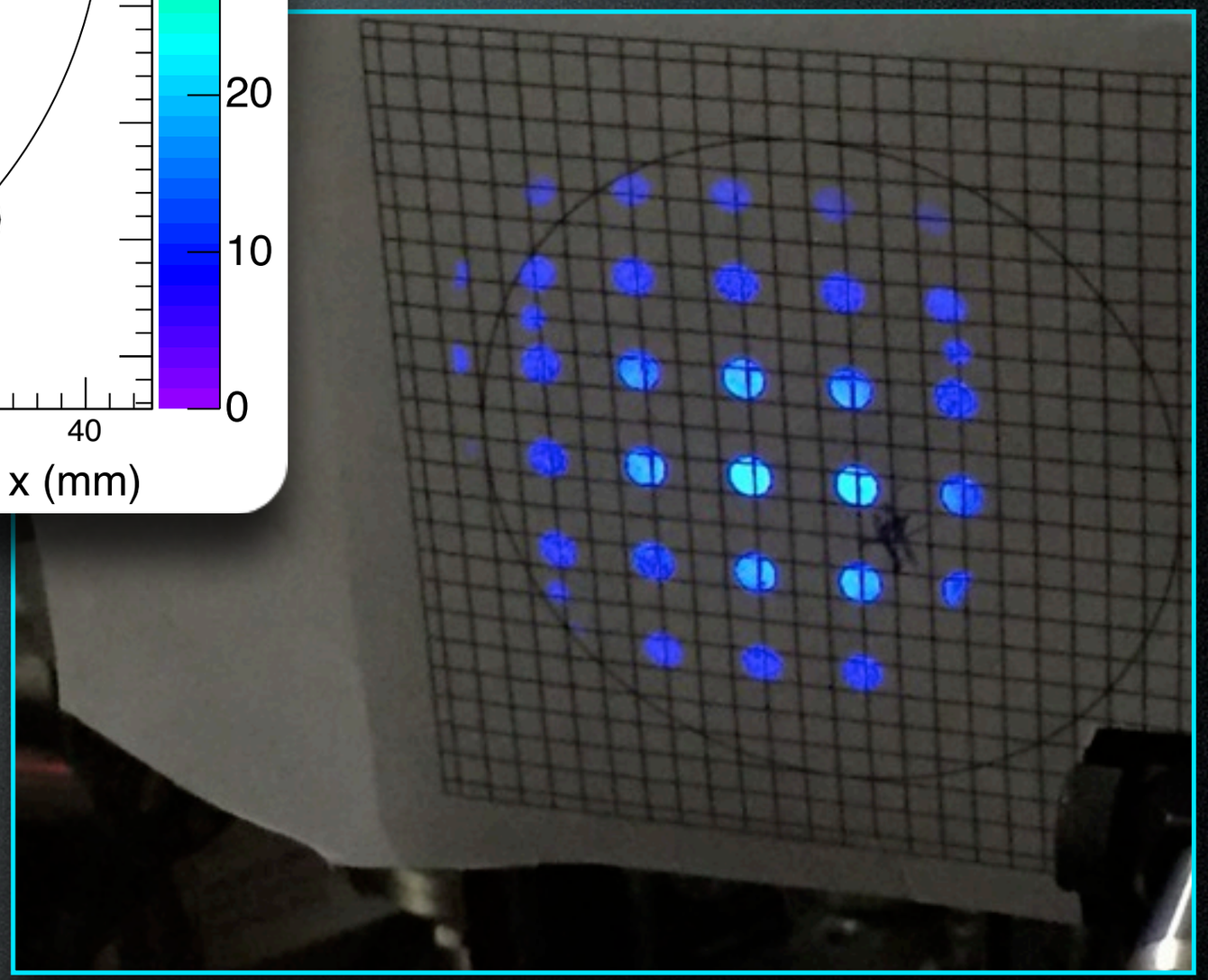

Preliminary Results: [1][2]
$\langle I \rangle / I = \{+0.992(1), -0.992(1)\}$

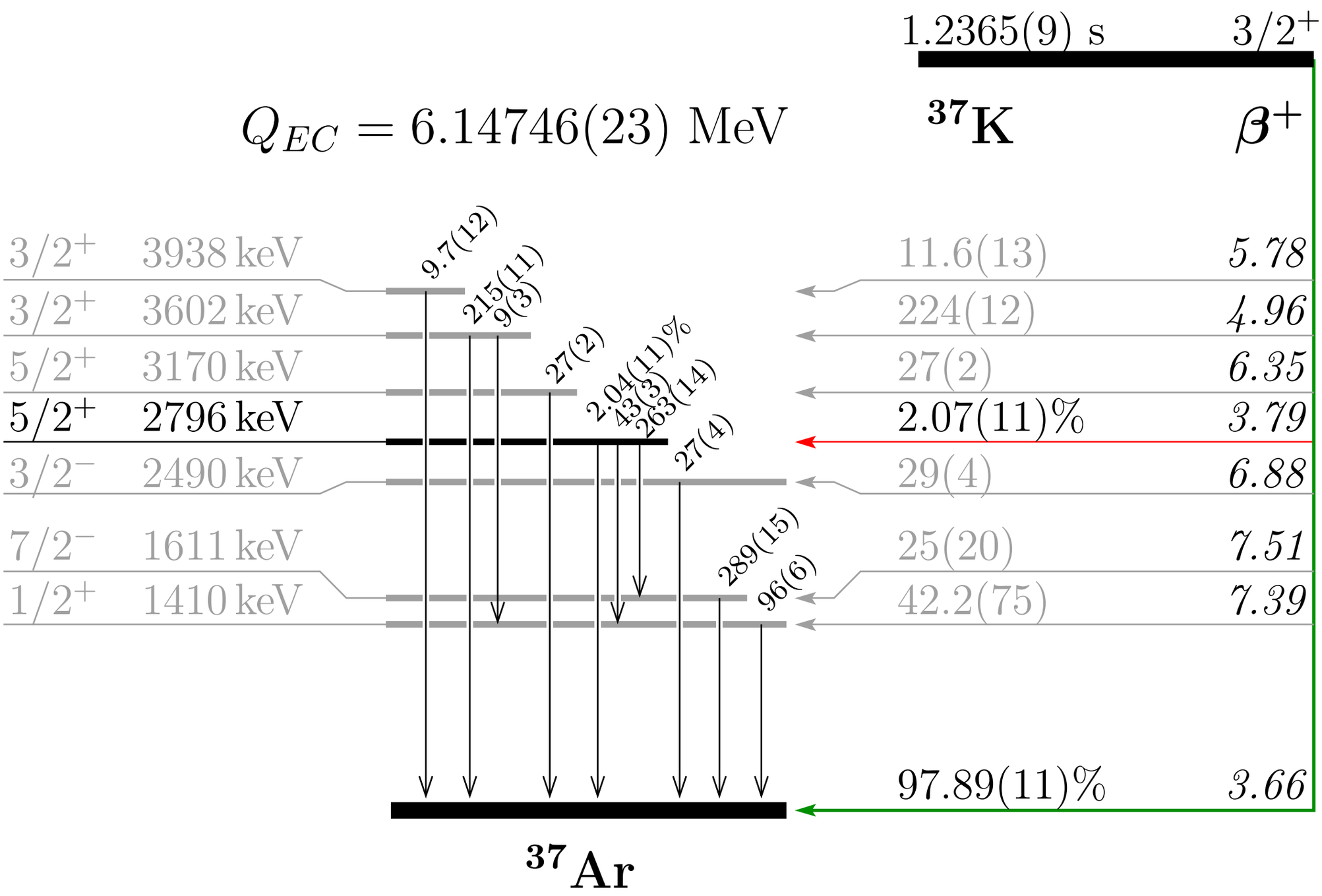


[1] B. Fenker et. al., in preparation.
[2] B. Fenker., SSP 2015

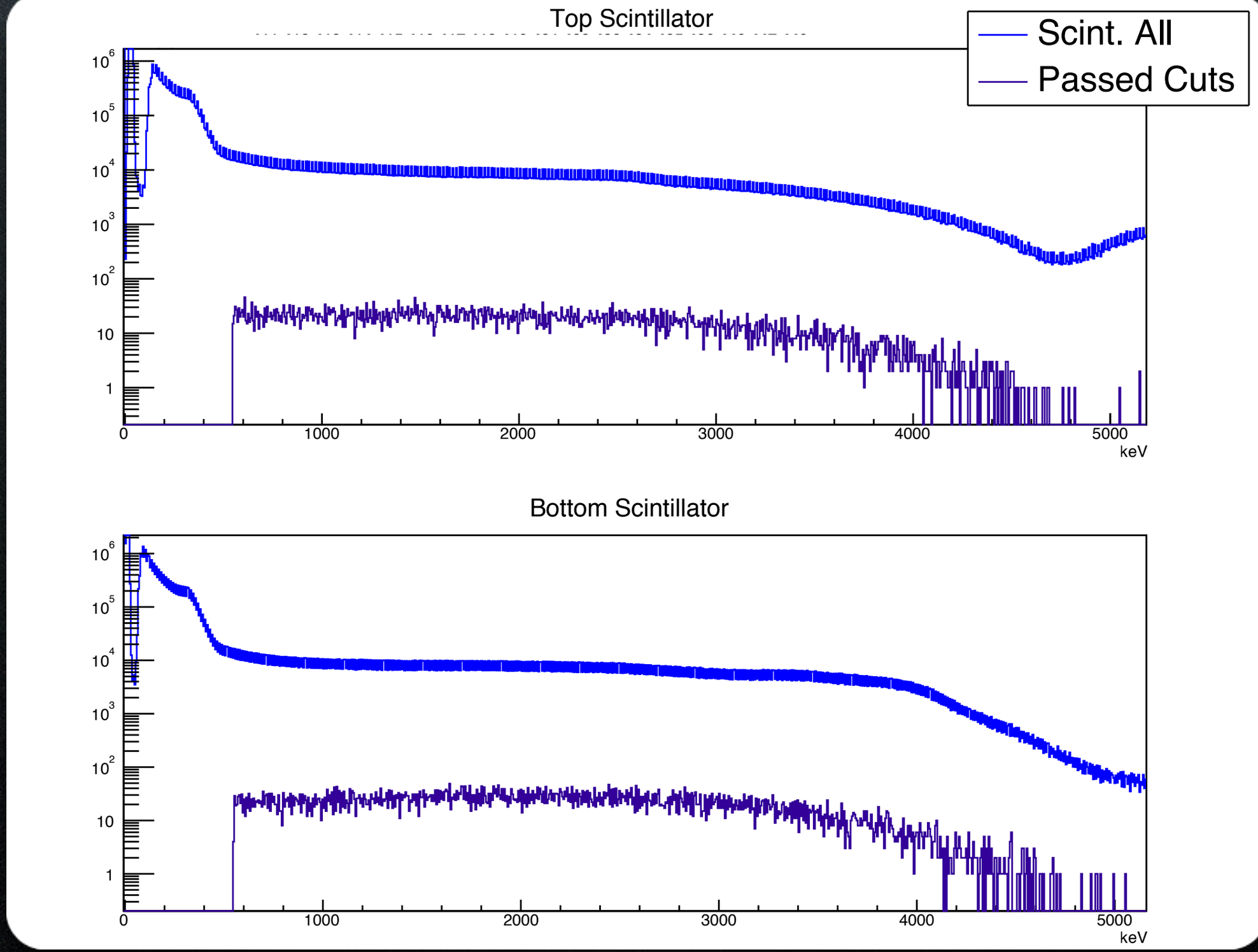
# Calibration via UV Laser






# $^{37}$K Decay Scheme




# Beta Energy Spectrum