Assembly and Commissioning of a New Multi-hit Charged-Particle Detector for Experimental Studies of Laser-Matter Interactions

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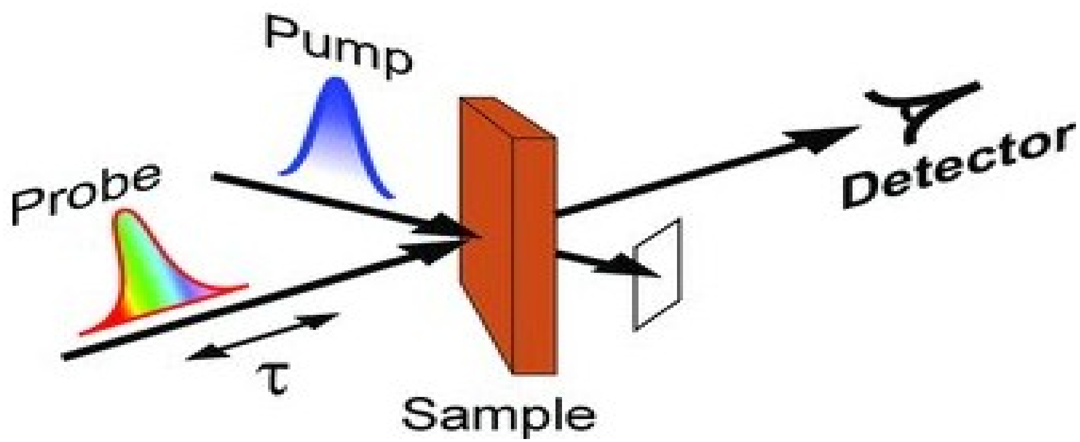
Laser-Matter Interaction Experiments

- Pump probe experiments



- Coulomb explosion experiments
  - These experiments can make "molecular movies"

Image retrieved from: https://www.researchgate.net/figure/51736360_fig8_Figure-1-Scheme-of-a-pump-probe-experiment-Reproduced-with-permission107-Copyright

How do we study these particles?

- **Spectrometer and detectors**
  - VMI (Velocity Map Imaging)

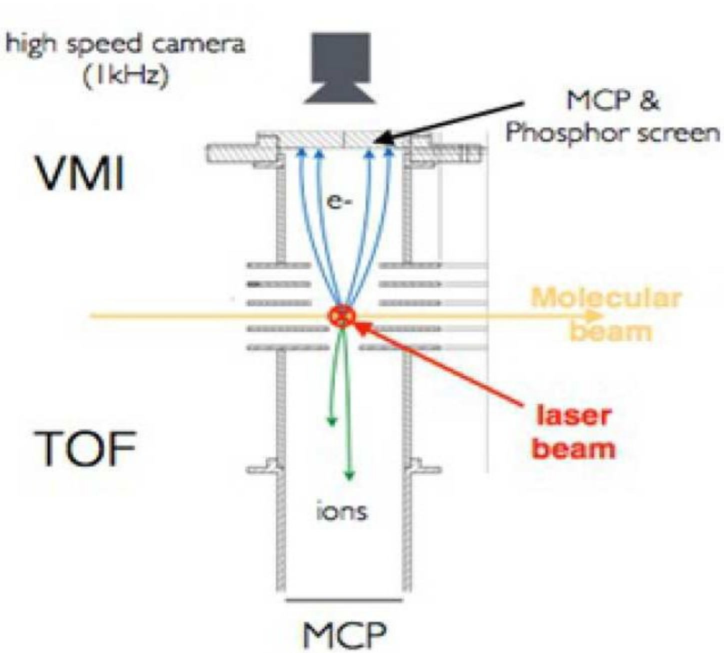
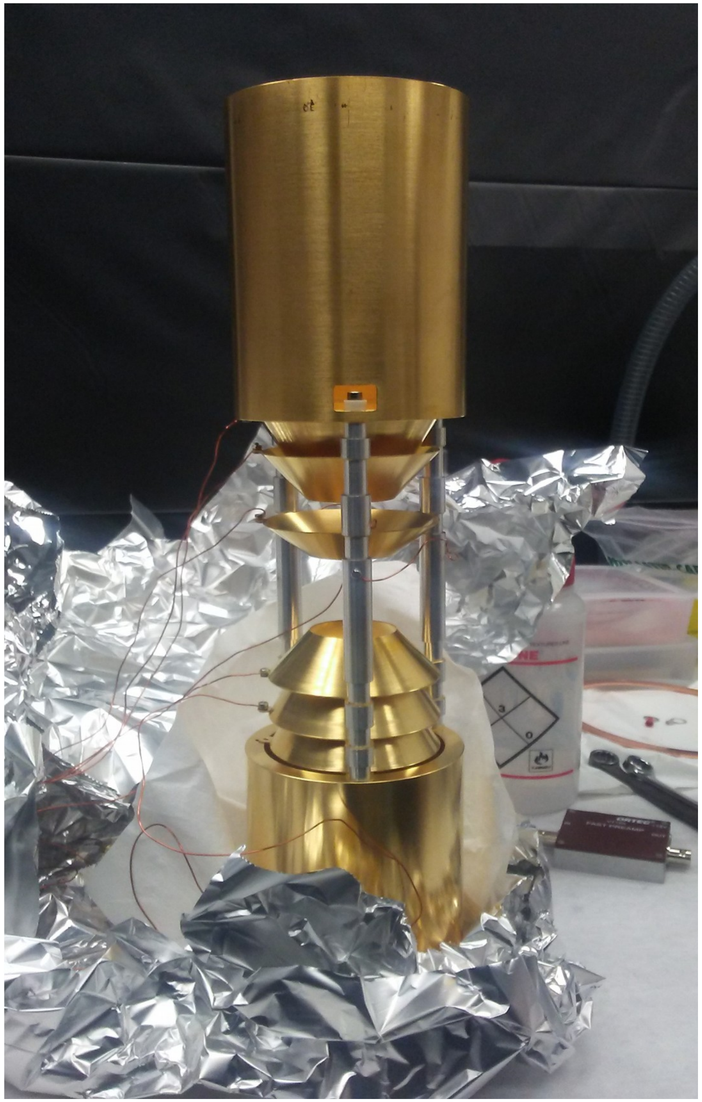


Image retrieved from: https://www.imperial.ac.uk/a-z-research/quantum-optics-and-laser-science/research/laser-consortium/current-research/attosecond-electron-dynamics/coupling-of-charge-migration-and-nuclear-dynamics/



Kansas Atomic and Molecular Physics (KAMP)

- **There are both ion and electron detecting sides (2 detectors)**
- **Detectors are multi-hit compatible**
- **Detector assembly consists of:**
  - Microchannel plates (MCP)
  - Position sensitive delay-line detectors (PSDs)
    - Quad and hex-anode (4-sided and 6-sided)

Microchannel Plates (MCPs)

- **Creates a cascade of electrons, generating a signal**
  - Usually a set of 2 plates in chevron configuration or a set of three plates in a ‘z’ configuration

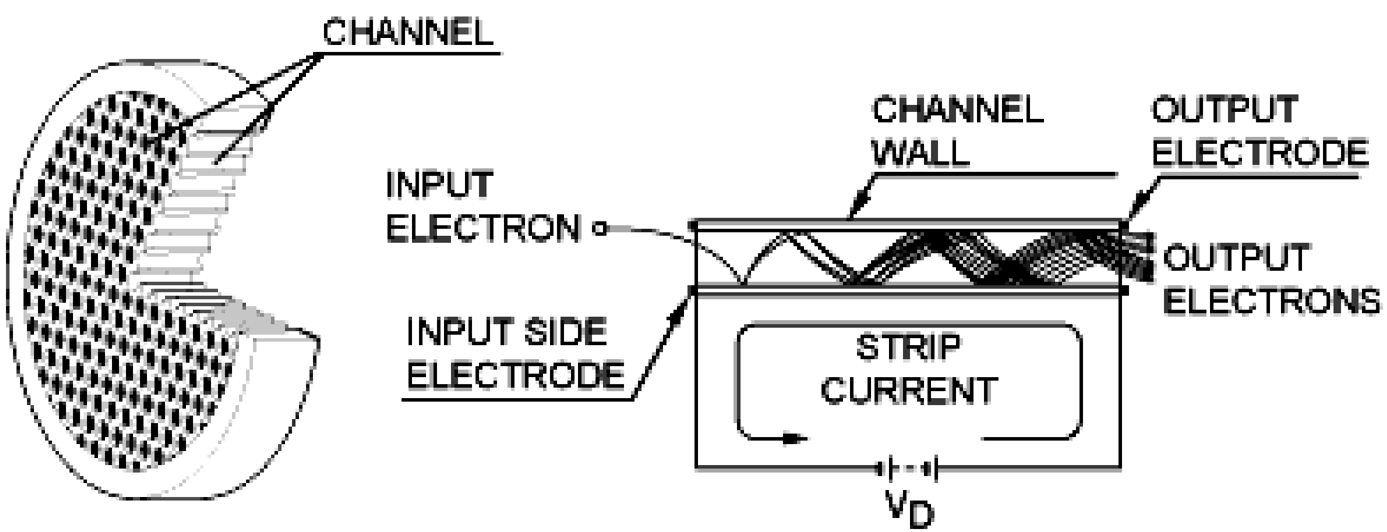
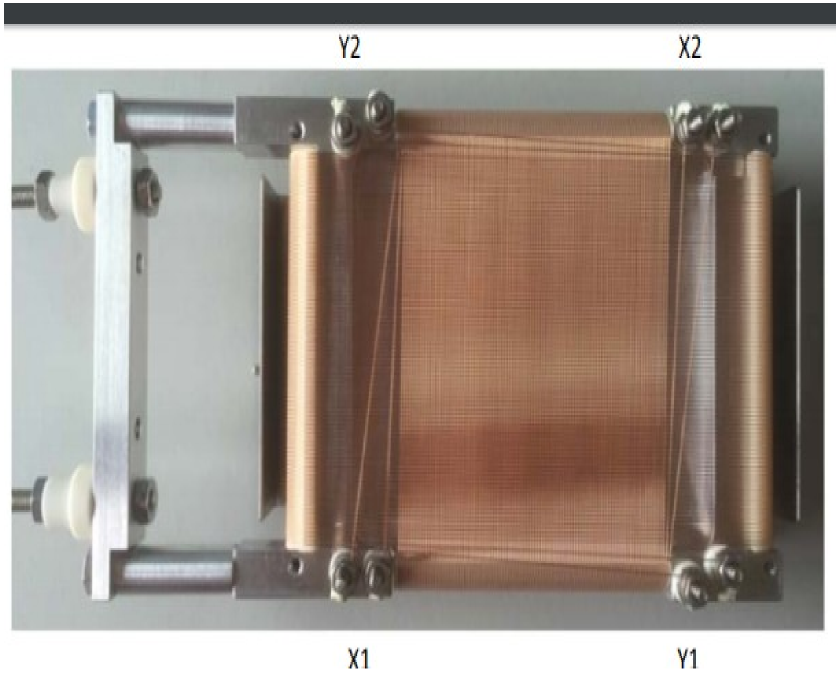
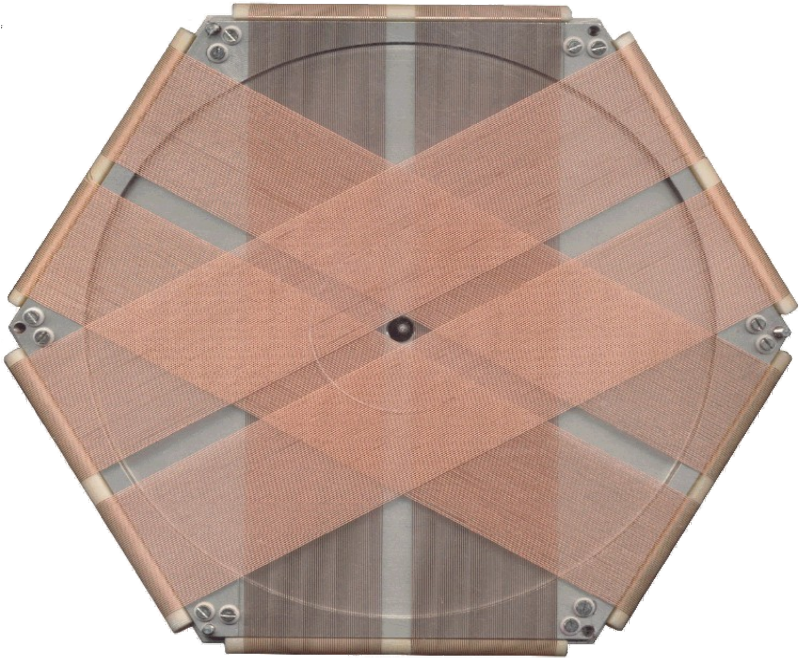


Image retrieved from: Maharjan, Chakra M. “Momentum Imaging Studies of Electron and Ion Dynamics in a Strong Laser Field.” Kansas State University, 2007.

Delay-line Position Sensitive Detectors

- 2 wires for each direction: signal and reference, kept at 50 volts apart
- The time it takes for a signal to propagate to each of the corners of the detector is mathematically converted into a position





Images retrieved from: Roentdek website and manuals

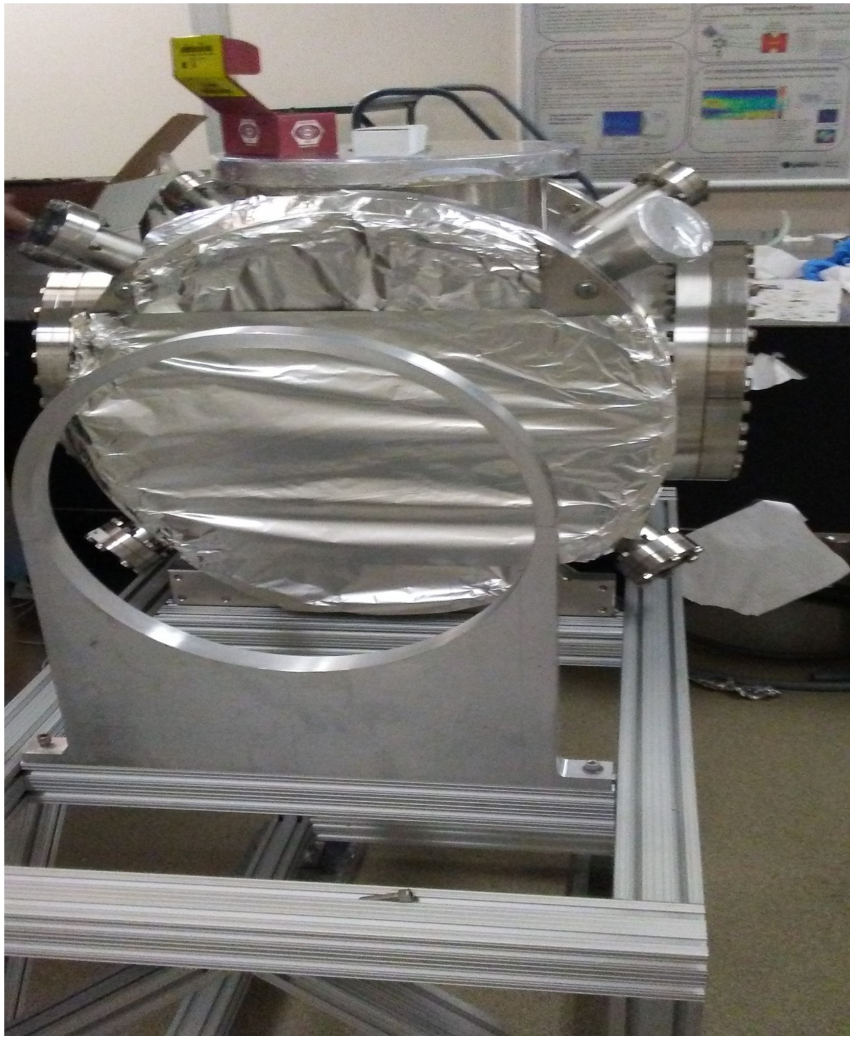
Why do we need KAMP?

- **Superior detection capability**
  - Hex-anode adds a layer of redundancy that makes it possible to resolve signals that land near the same location around the same time
- **Detects both ions and electrons simultaneously**
  - This leads to new and more data that can be used in Coulomb explosion and other molecular imaging experiments

Assembly of the Detector

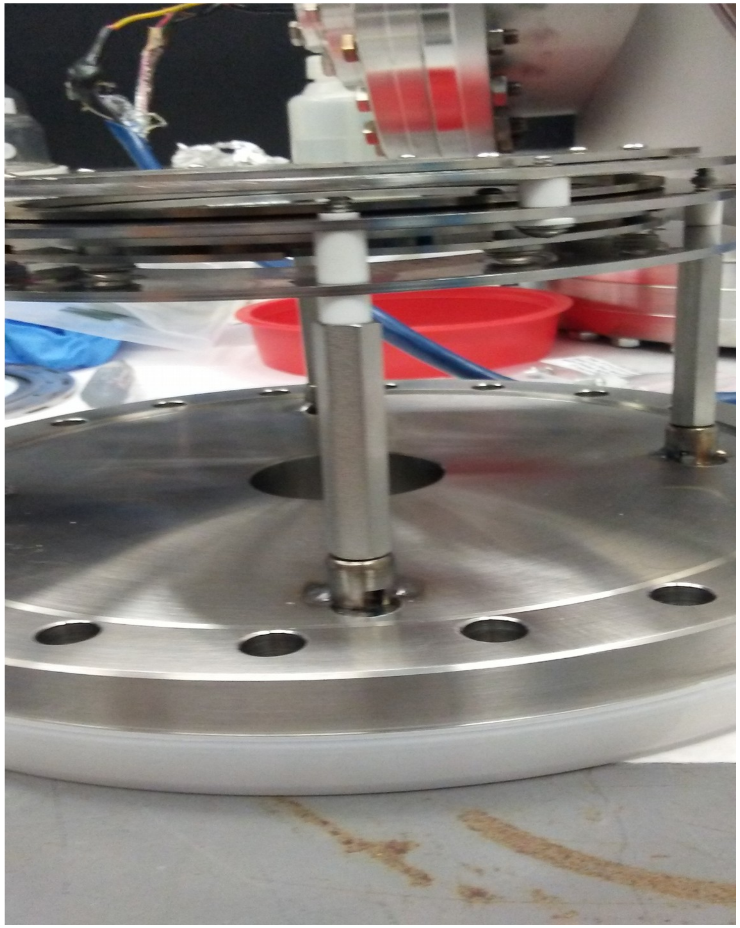
- **Location: Clean room in JRML**
- **Rough procedure:**
  1) Get all parts and make sure they are in order
  2) Practice assembling detector plates with “dummy” MCP
  3) Clean all parts when ready for real assembly
  4) Put together the detector, wire it, and install into the test chamber
  5) Test dark counts from the detector with oscilloscope

KAMP Main Chamber



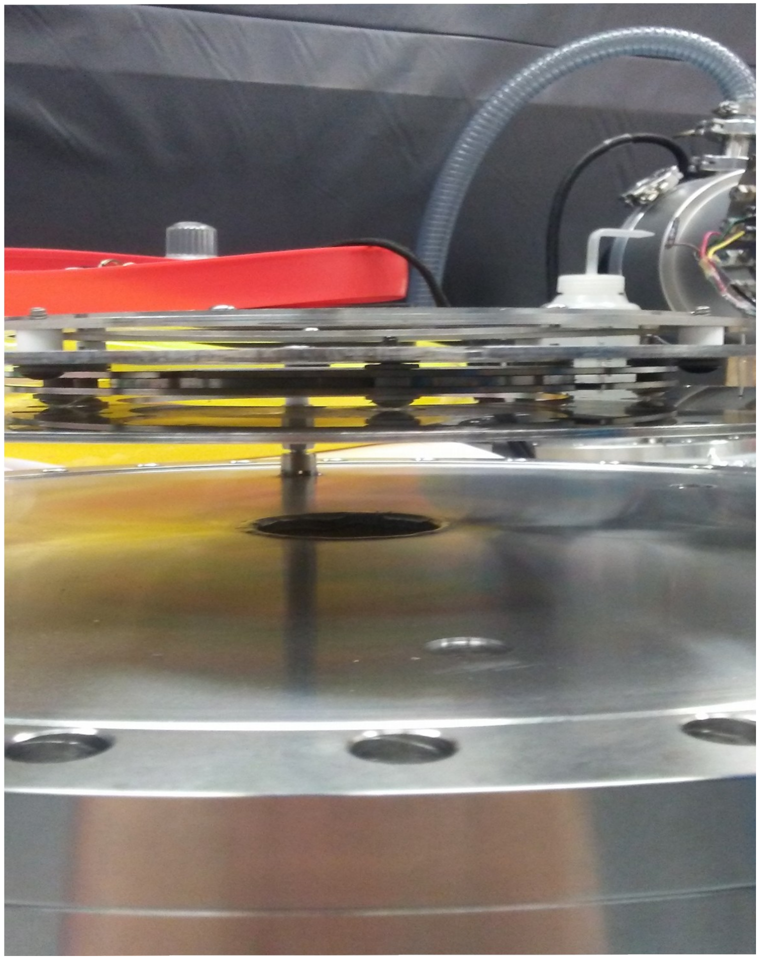
“Dummy” MCP Installation of Detectors

- Quad-anode side



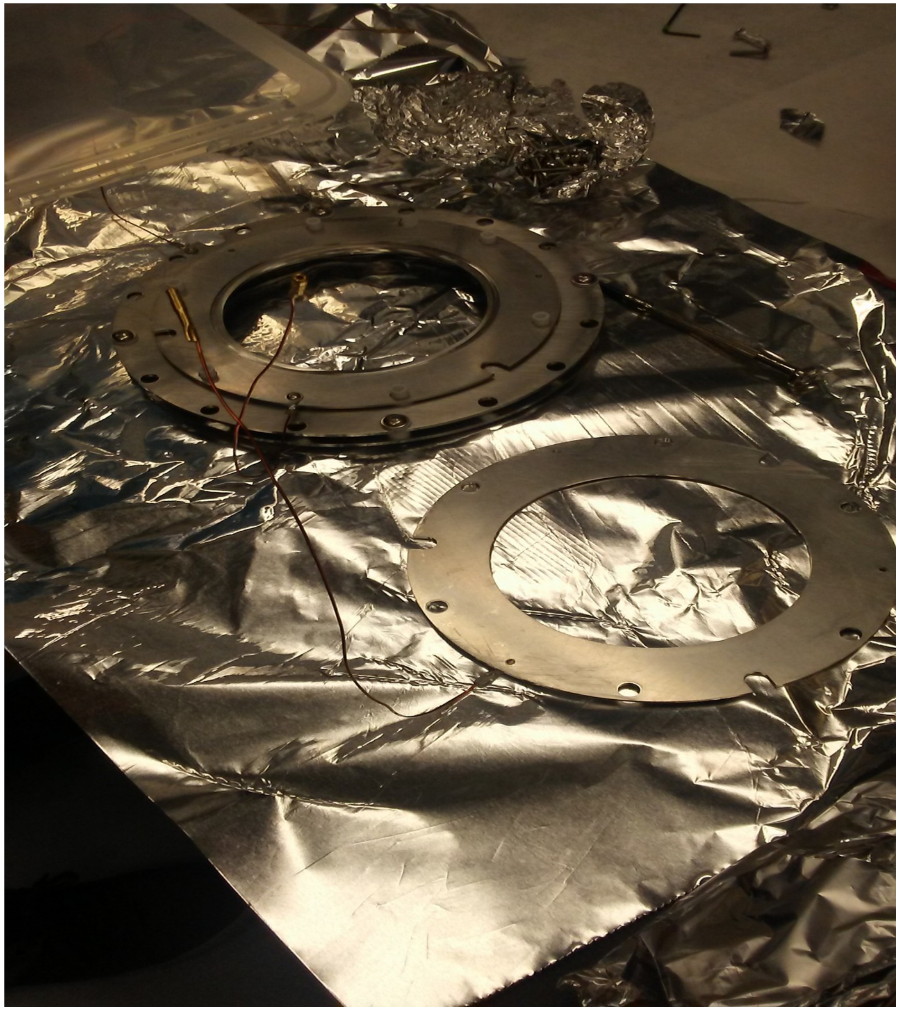
“Dummy” MCP Installation of Detectors

- Hex-anode side

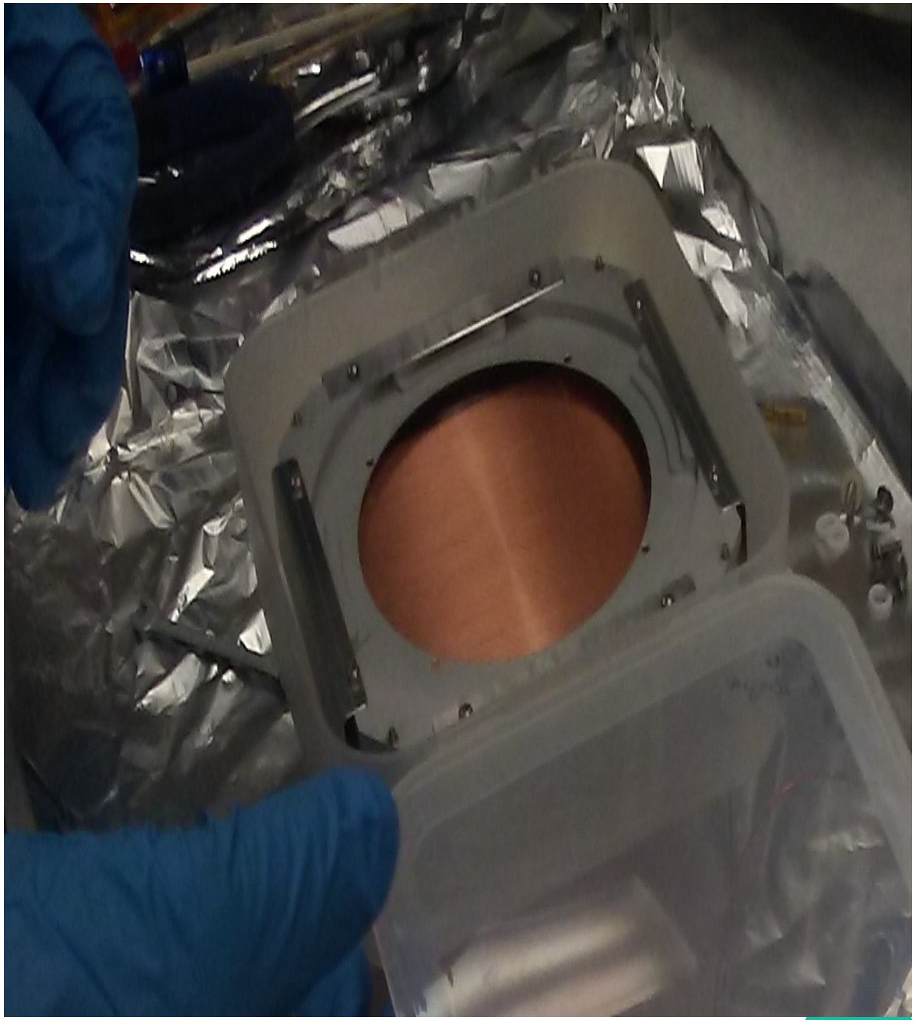


True Assembly and Putting into Test Chamber

MCP wire hookups

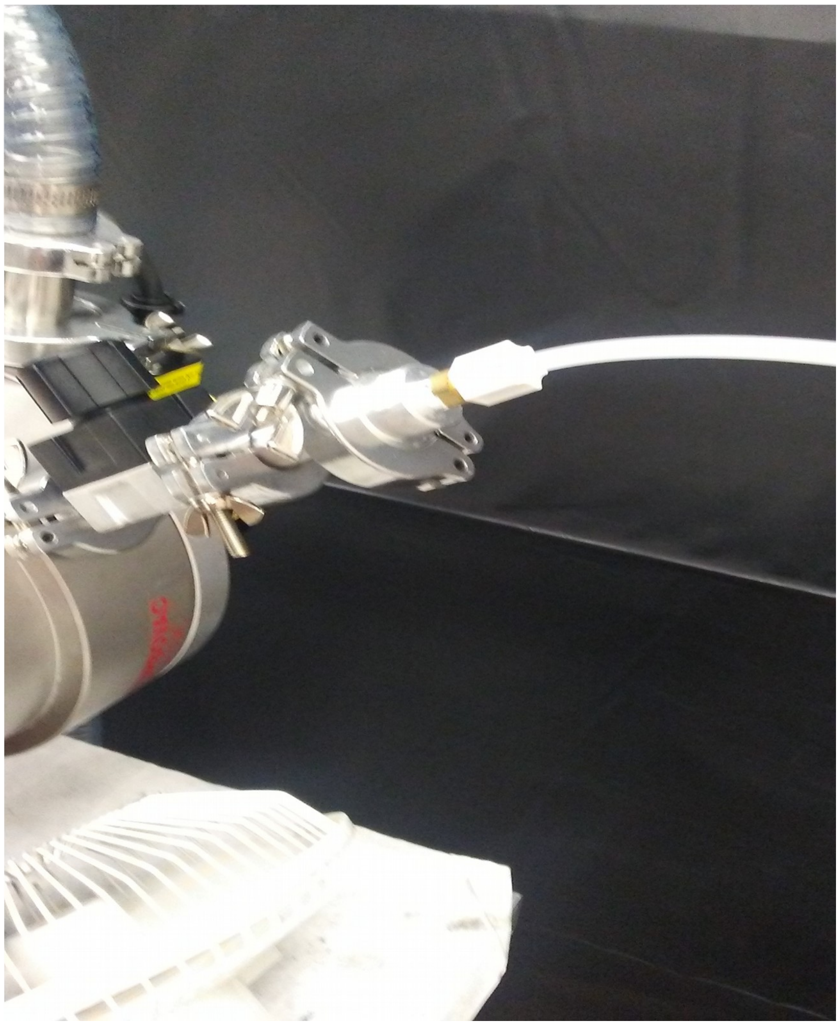


Delay-line quad detector

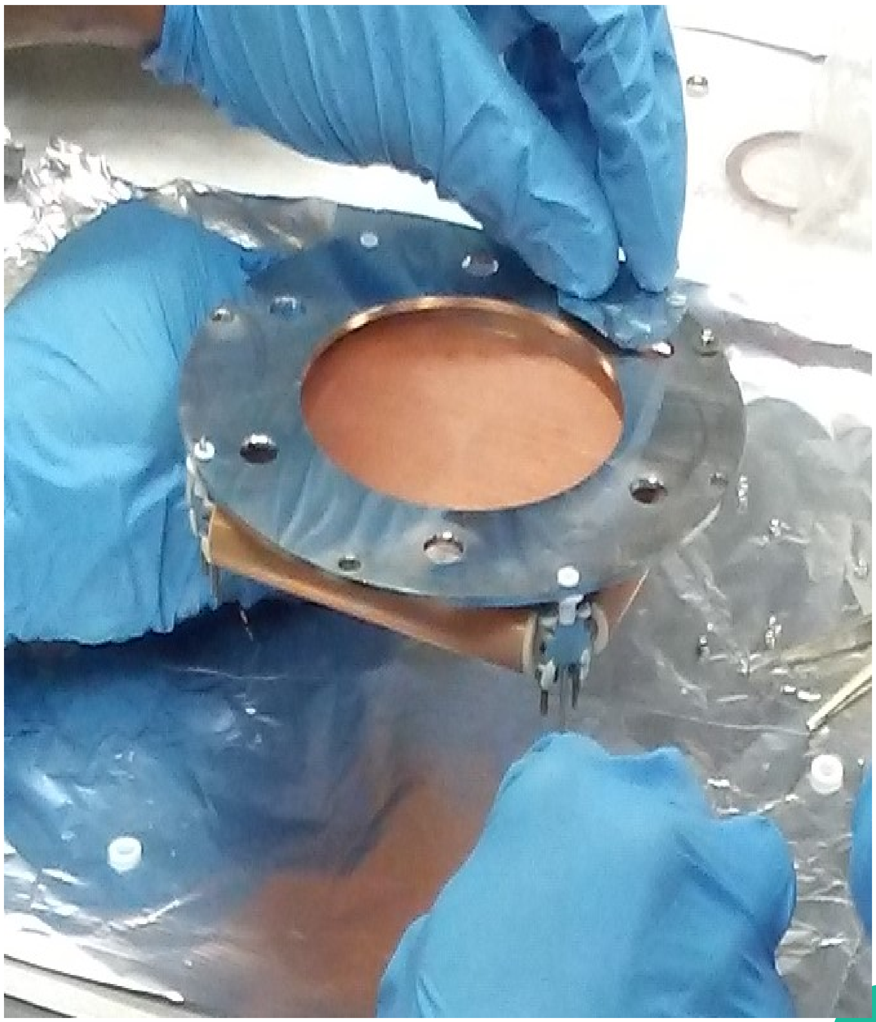


True Assembly and Putting into Test Chamber

Venting the chamber

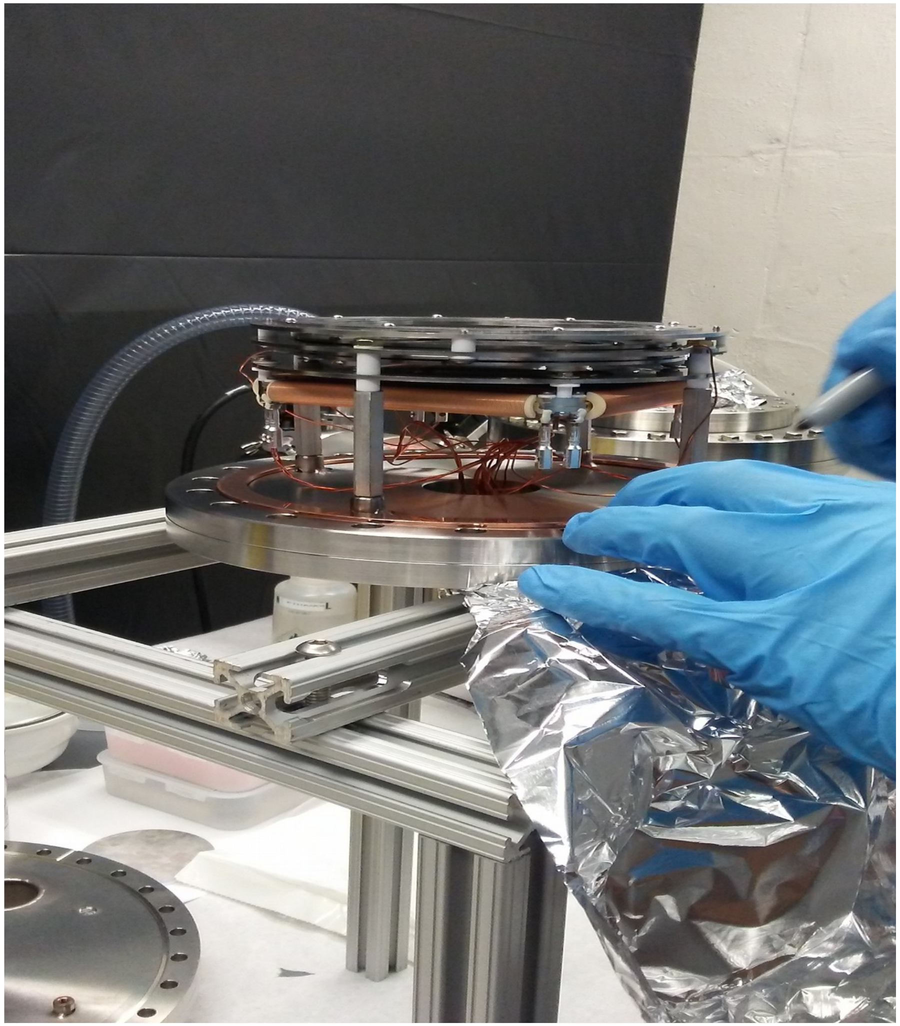


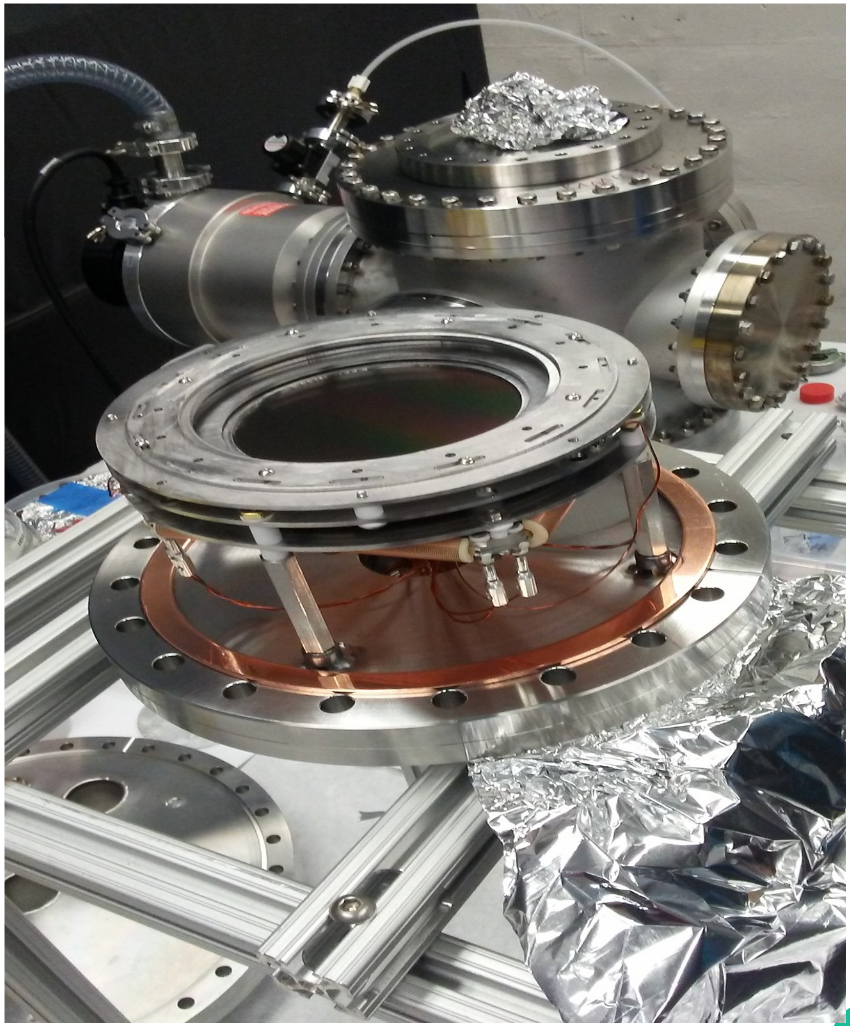
Mounting the delay-line



True Assembly and Putting into Test Chamber

Complete MCP/Delay-line Assembly!

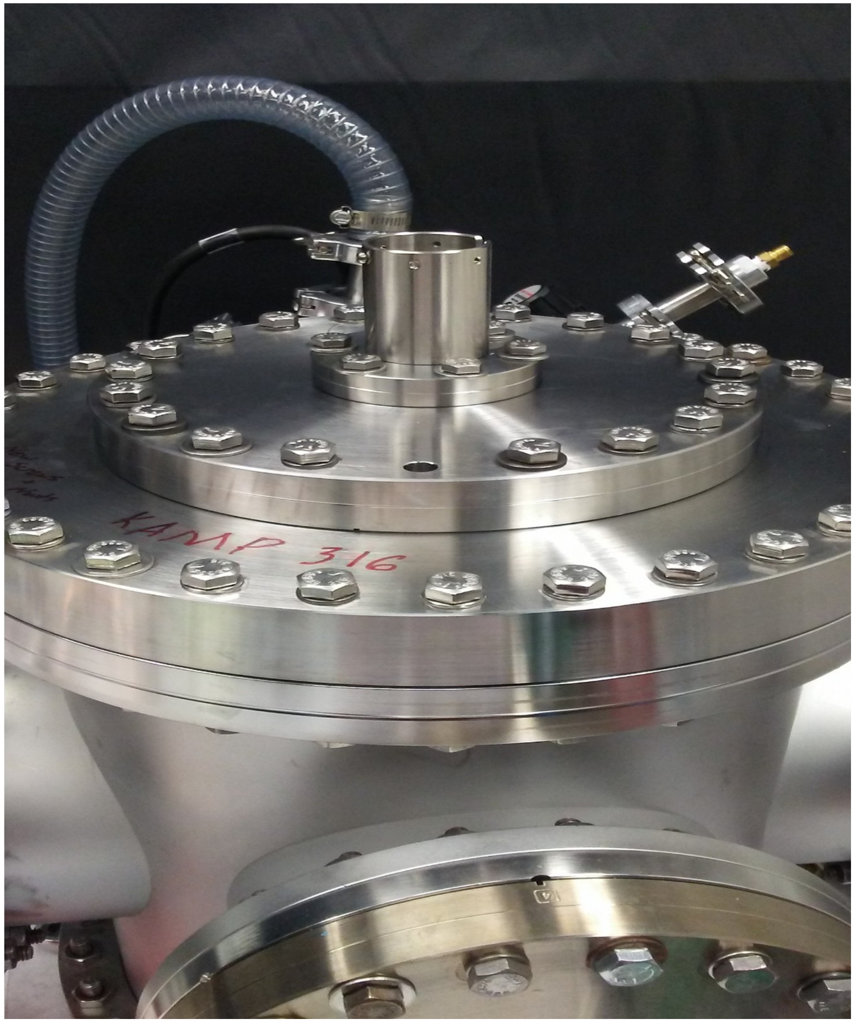




Vacuum Technology

- **To achieve very high vacuum (on the order of 10^{-9} Torr):**
  1) Must be pumped down to about 10^{-3} Torr with roughing pump
  2) Pumped down further with turbo pump
  3) Baking chamber allows water to evaporate, bringing the pressure down the rest of the way
  - For our purposes (in the interest of time), we will only do the first two steps now

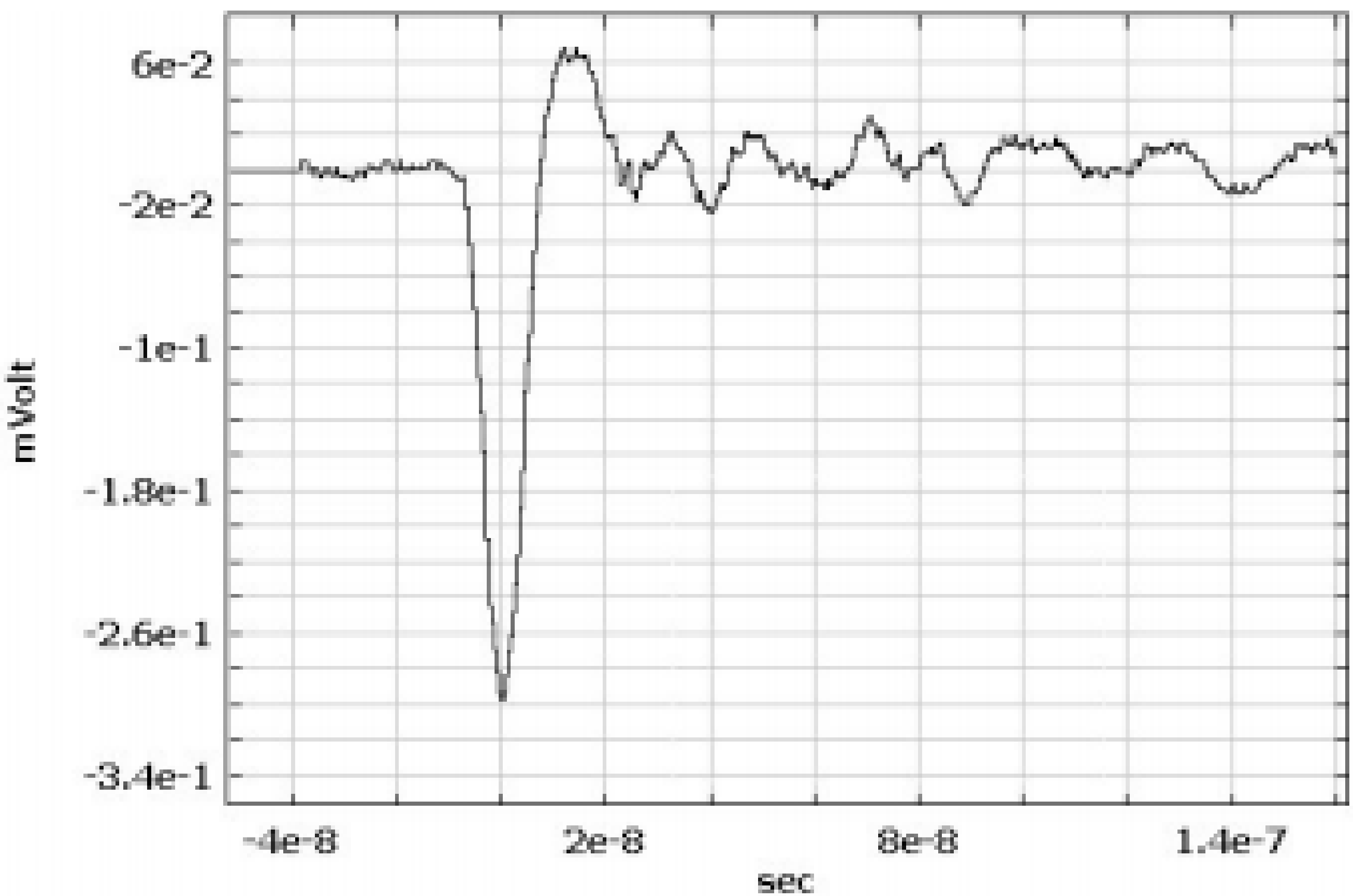
Pumping Down the Chamber



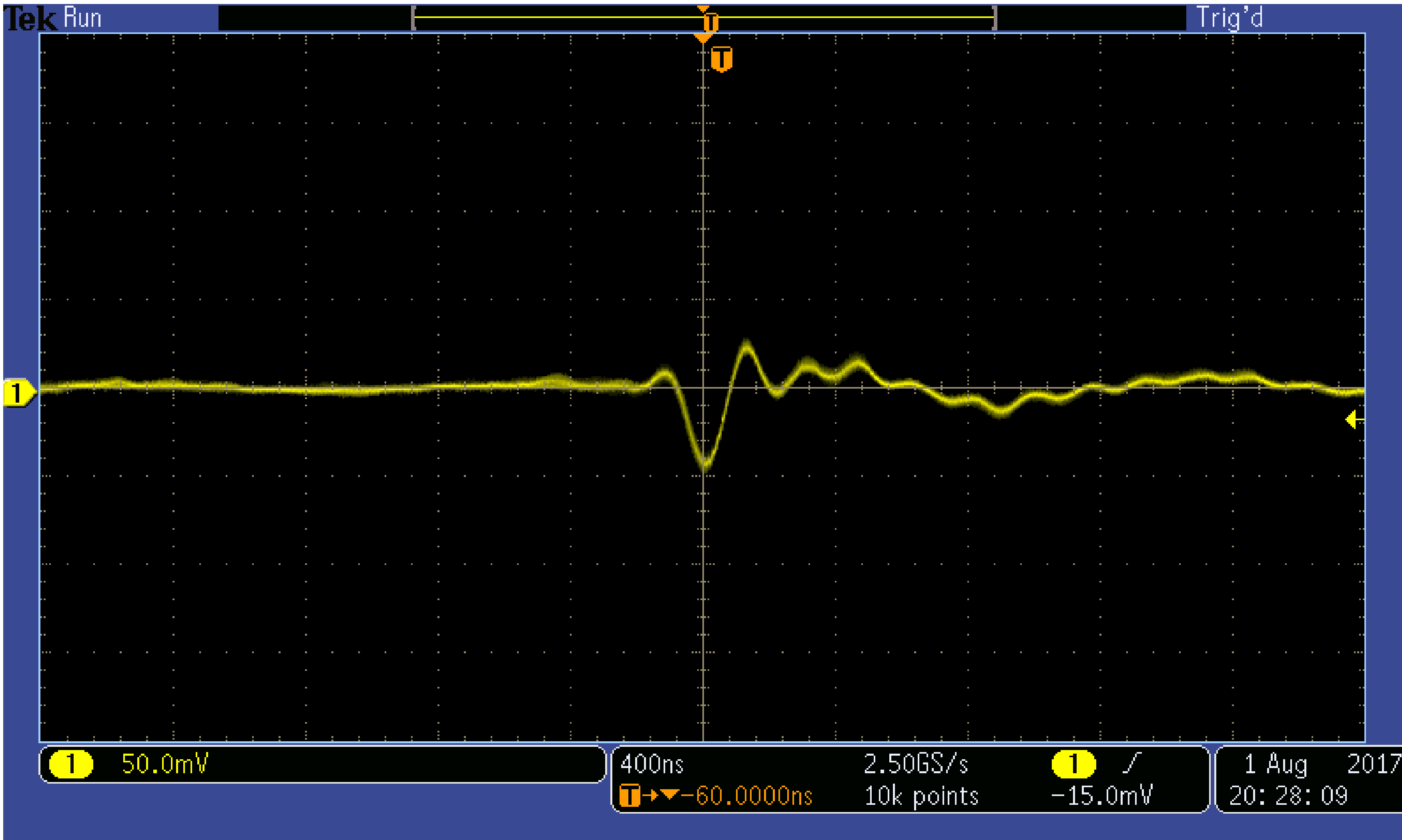
Dark Count Testing

- **What are dark counts?**
  - Signals generated by the MCP automatically when voltage is applied
  - Can be used to test detectors without needing a laser or a sample

Typical Pulse Shape from MCP



Dark Count Testing: Seeing the MCP Signal



Summary and Looking Forward

- The main spectrometer chamber and quad-anode detector are assembled
- MCP signals were observed in the testing chamber
  - MCP is operational
- Same procedure needs to be repeated for hex-anode detector side
- Eventually, both detectors will be mounted in the main KAMP chamber

Acknowledgments

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References

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