Time of flight identification of ions around accelerated beams

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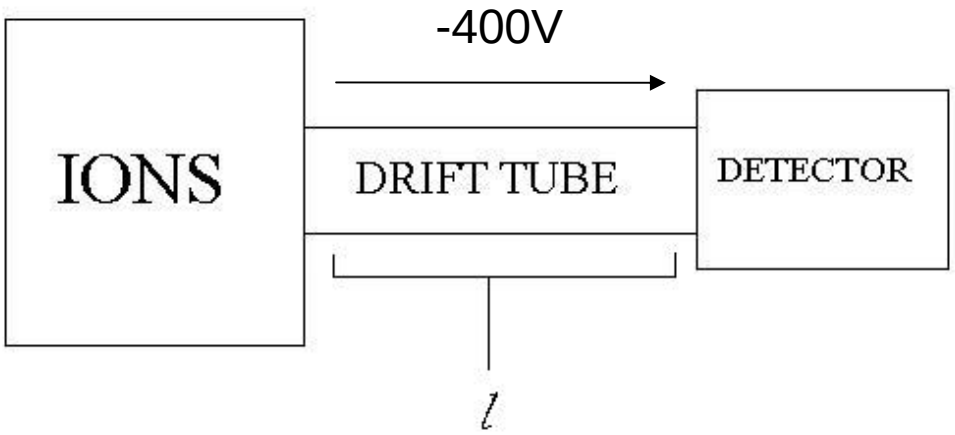
- **Ion densities in the beam pipe from scattering on the dilute gas**
- **Ions can then effect the motion and emittance of the beam, for example:**
  - **Fast ion instability**
    - coupling between ions and the beam propagates down the train and severely disturbs the later bunches
  - **Non-linear focusing**
    - 1/r accumulation of the ion density around the beam results in emittance growth
- **So we want to identify the ions in the beam pipe - primarily to evaluate the viability of various ion clearing methods**
  - **G.H. Hoffstaetter, C. Spethmann, Physical Review ST-AB 11, 014001 (2008)**
- **My project has been constructing a time-of-flight experiment to install on the ERL gun and identify the ions**

- **A First Look:**



$$\frac{1}{2}mv^2 = qV$$

$$t = \frac{l}{v}$$

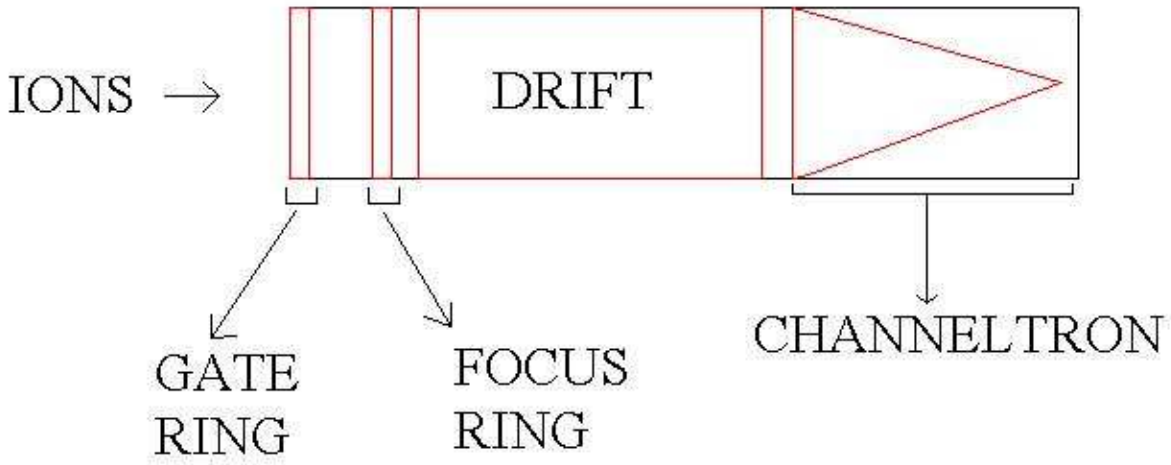
$$t = \frac{l}{\sqrt{2V}}\sqrt{\frac{m}{q}}$$

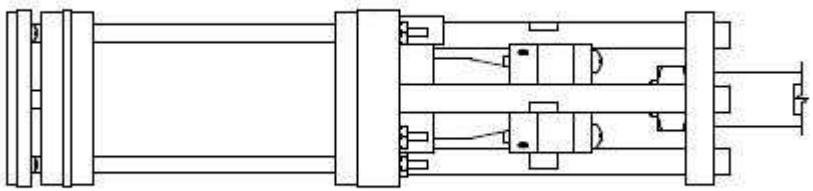
- **Required temporal resolution: 0.05 micro-second**

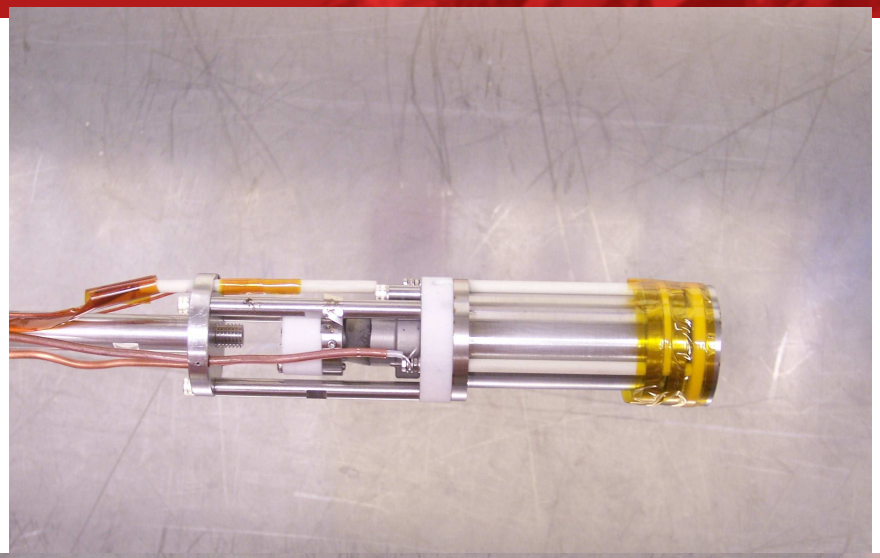
$$\Delta t = \left(\frac{l}{2} \sqrt{\frac{m}{2qV}} \right) \frac{\Delta m}{m}$$

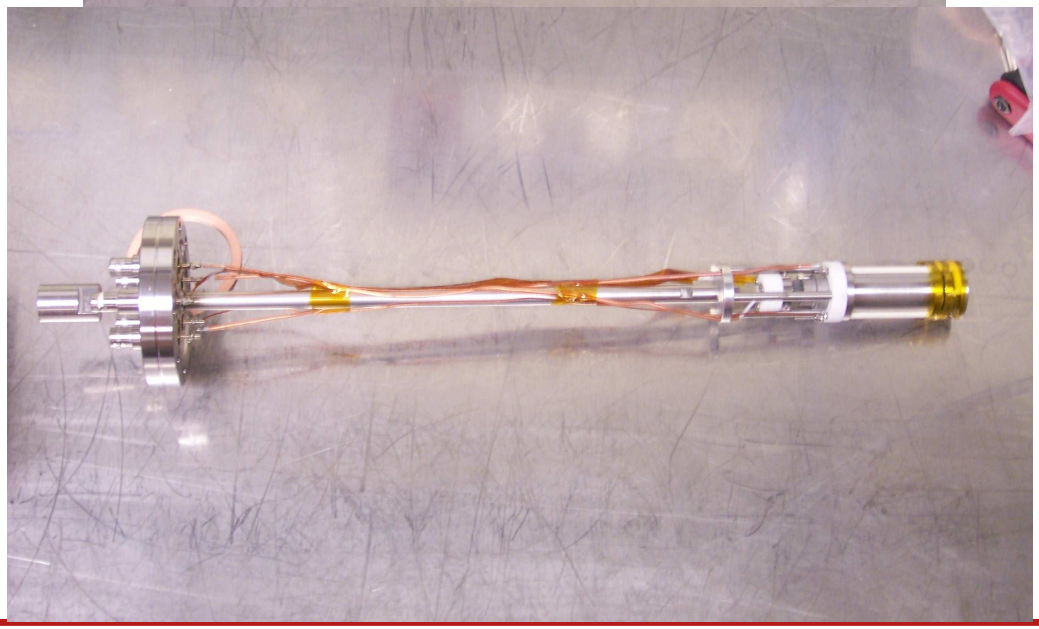
- **Actual detector encompasses the gate ring, focus ring, drift chamber, and detector**
  - **Rest of the apparatus used to measure the signals from the detector and achieve appropriate resolution**
- **The detector is an electron multiplier, a 'Channeltron', which converts incident ions, via an electron cascade, into a measurable signal**
- **Gate ring gates the flow of ions into the detector**
- **Focus ring focuses ions into the detector at -200V**
- **Drift chamber imparts -400V to the ions per TOF scheme**

- **The detector:**

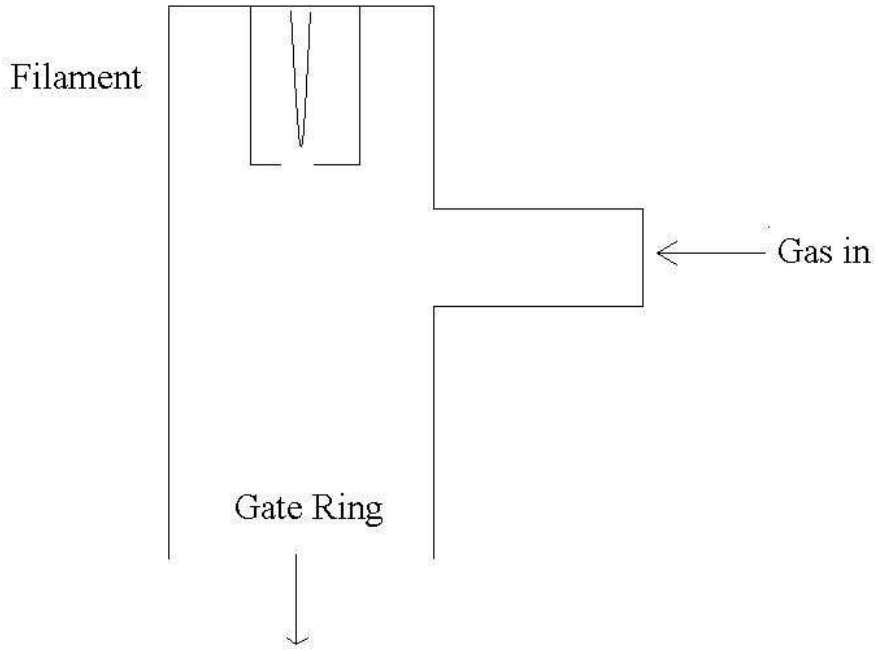


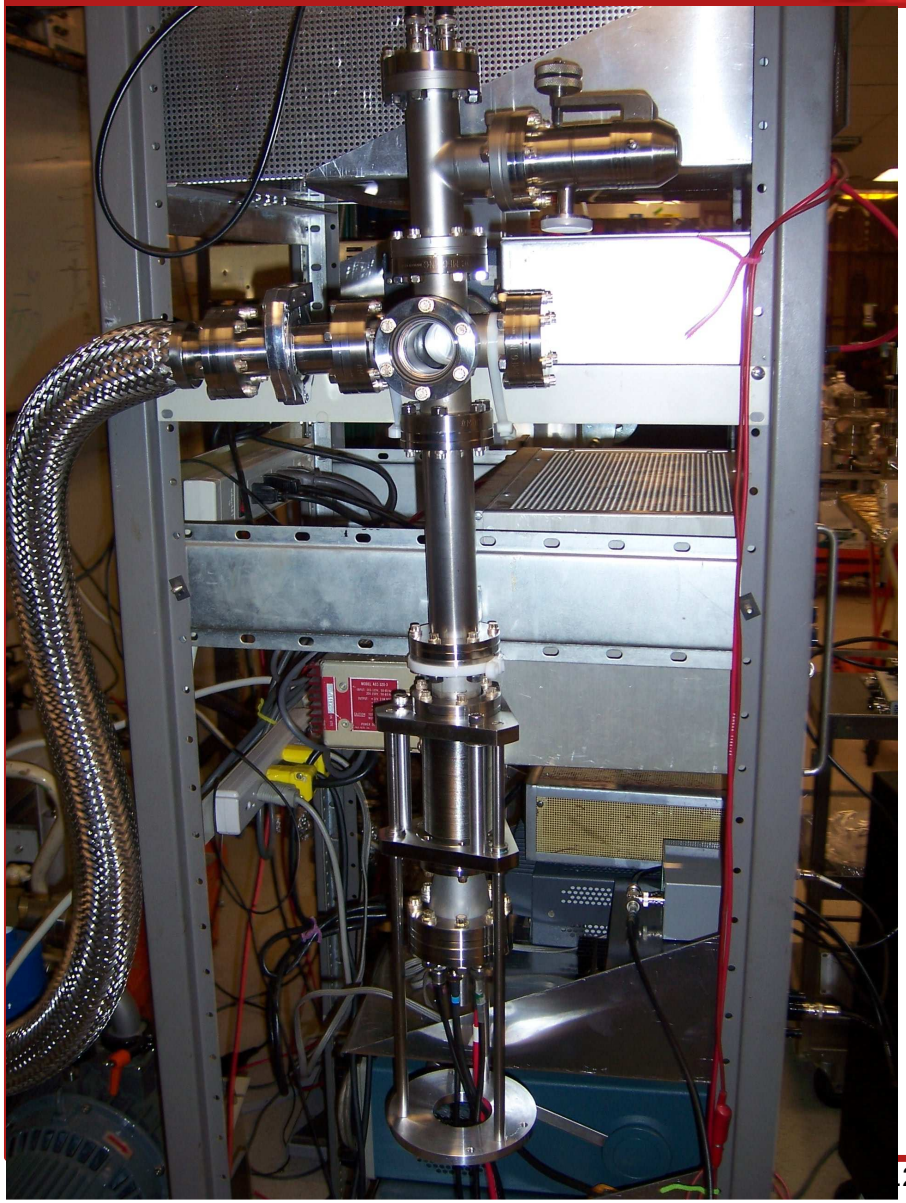




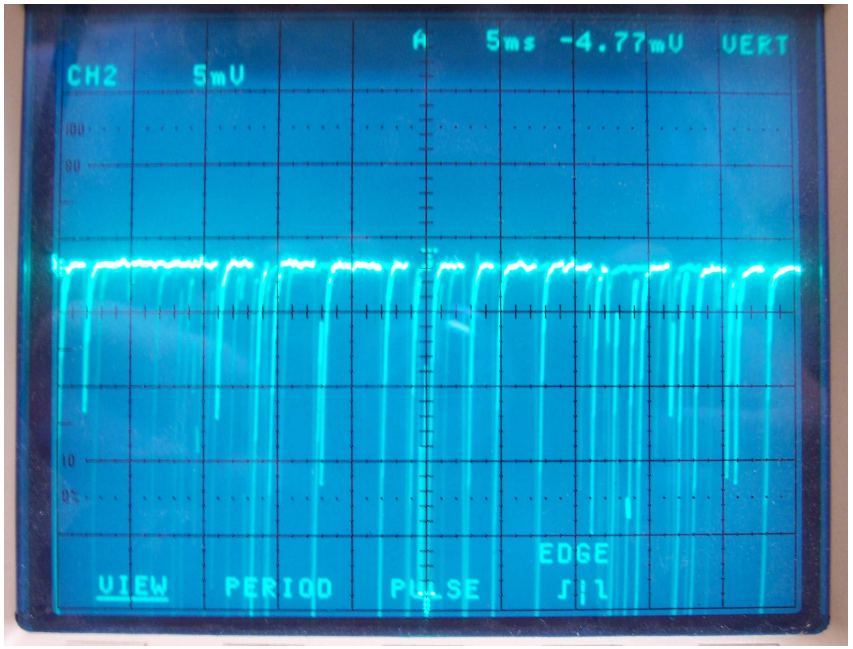


- **Test assembly:**
  - **Filament heated to generate electrons to scatter on gas and produce ions**
  - **Leak valve installed to allow control of gas concentrations for calibration of the detector**





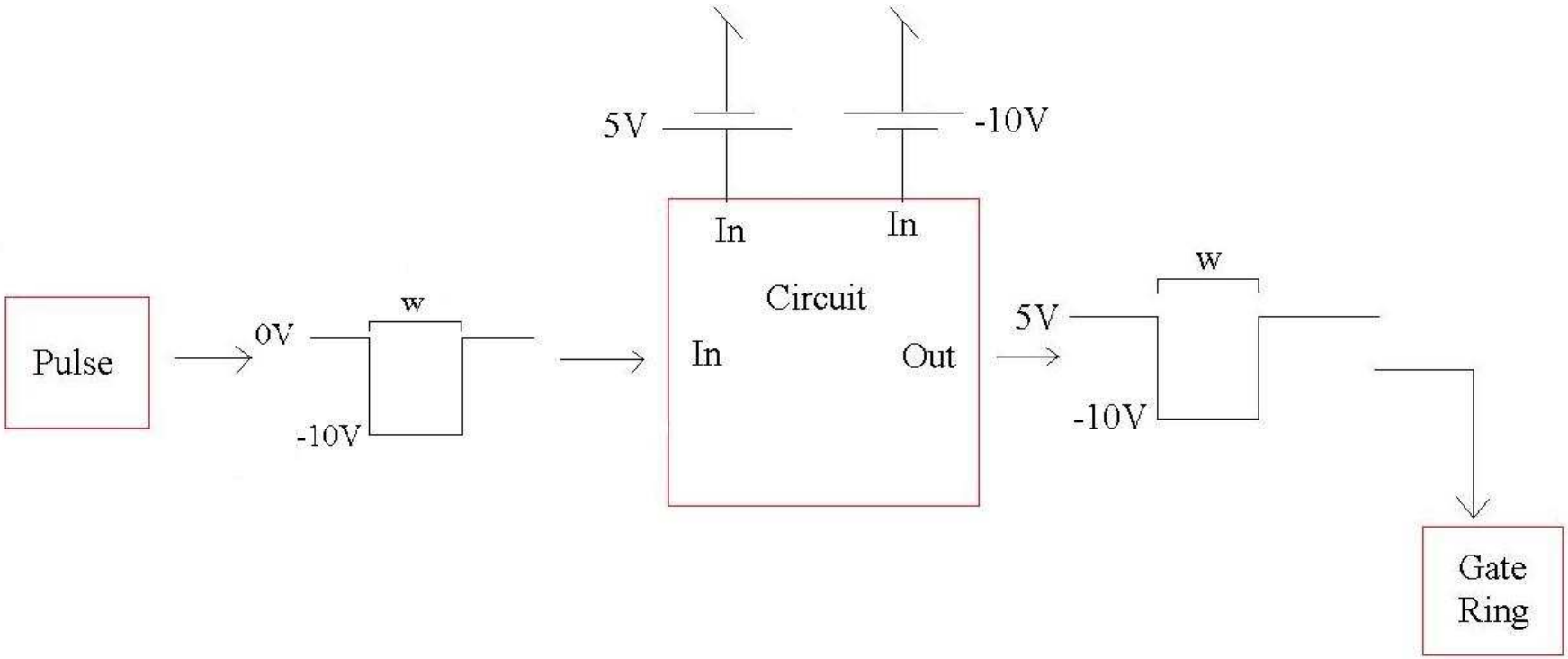
Test assembly and detector



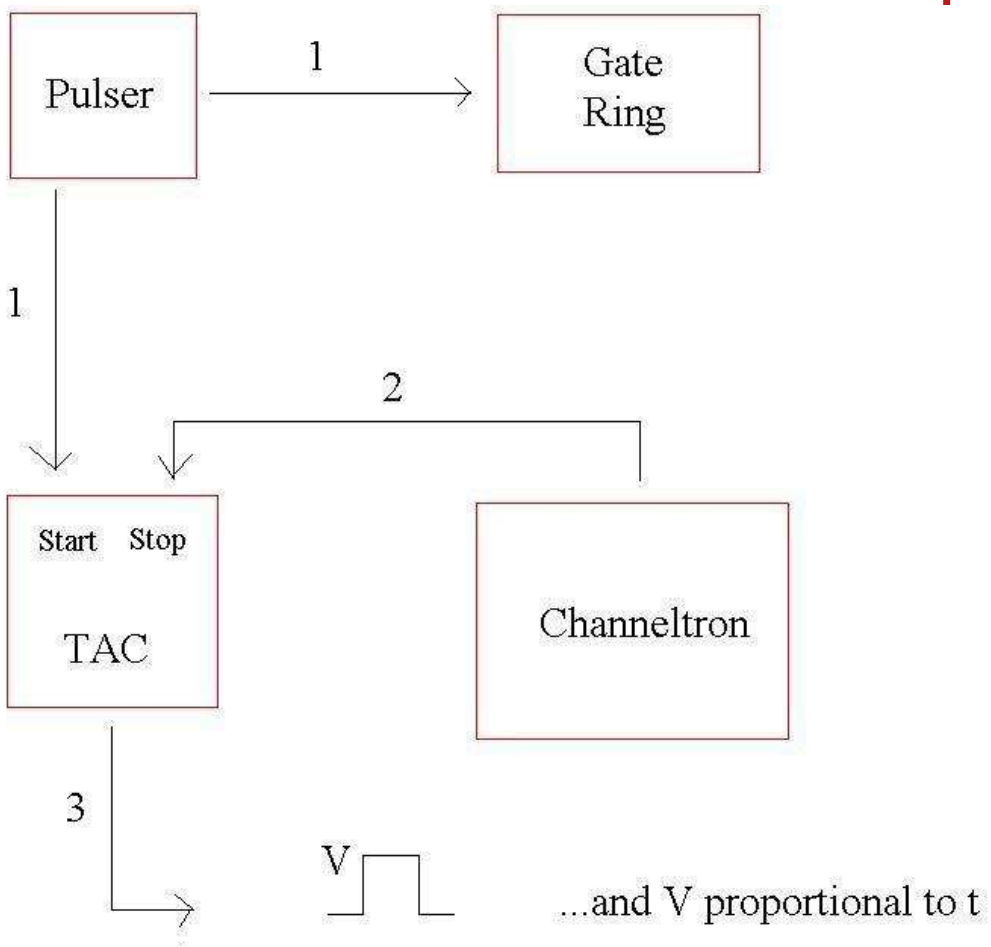
Ion signals on oscilloscope

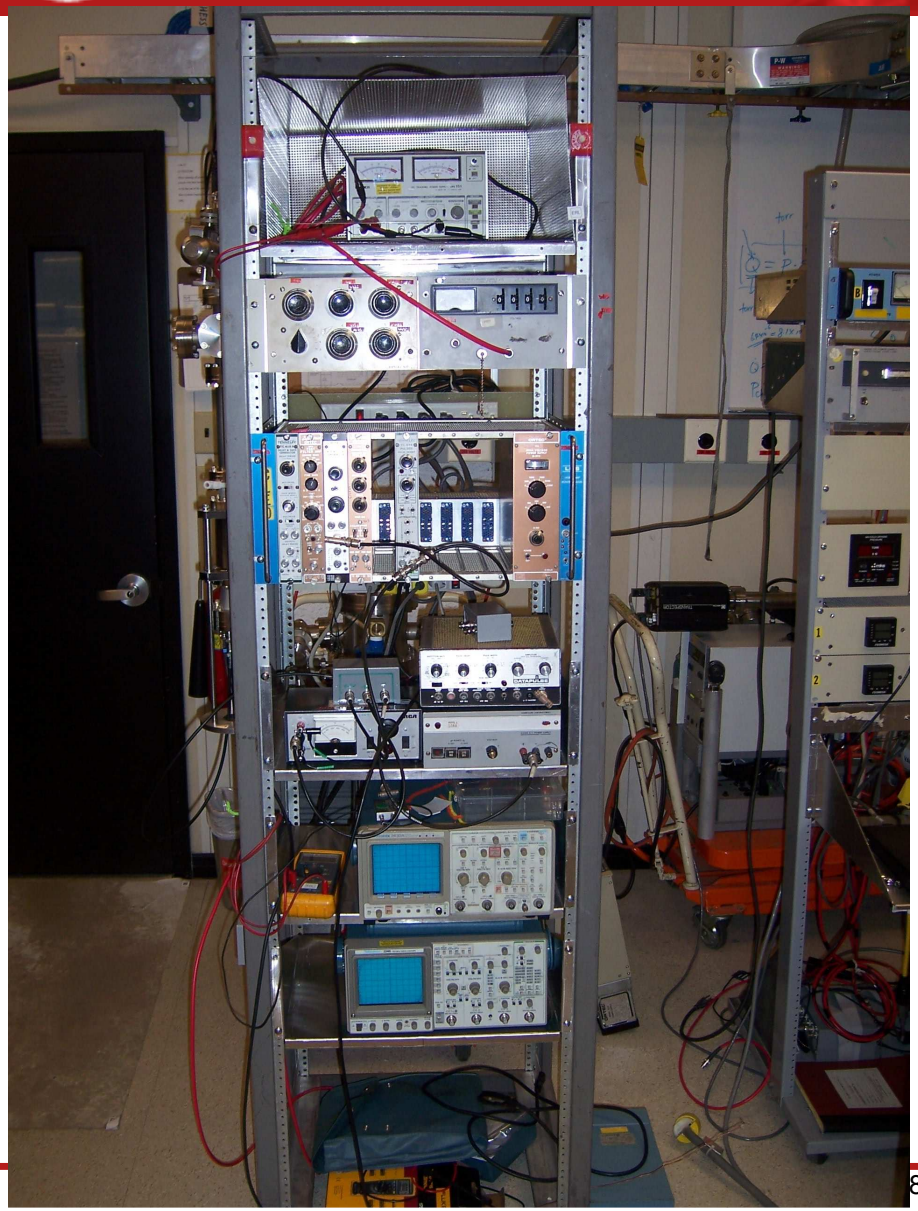
- **To start TOF measurements,**
  - **Pulse the gate ring to discharge it and allow the ions to enter the detector**
  - **Use the same pulse to trigger a measurement device**
  - **Watch for the first signals from the Channeltron**
  - **Use a time-to-amplitude converter to generate a pulse with an amplitude proportional to the time between the start pulse for the gate ring and the pulse from the Channeltron**
- **In this manner, we can get the distribution we are looking for**
  - **A distribution of no. of ions versus time, and calculate the relative concentration of different ion species/charge of the ion density in the beam pipe**

- **TOF begins on switching gate ring:**



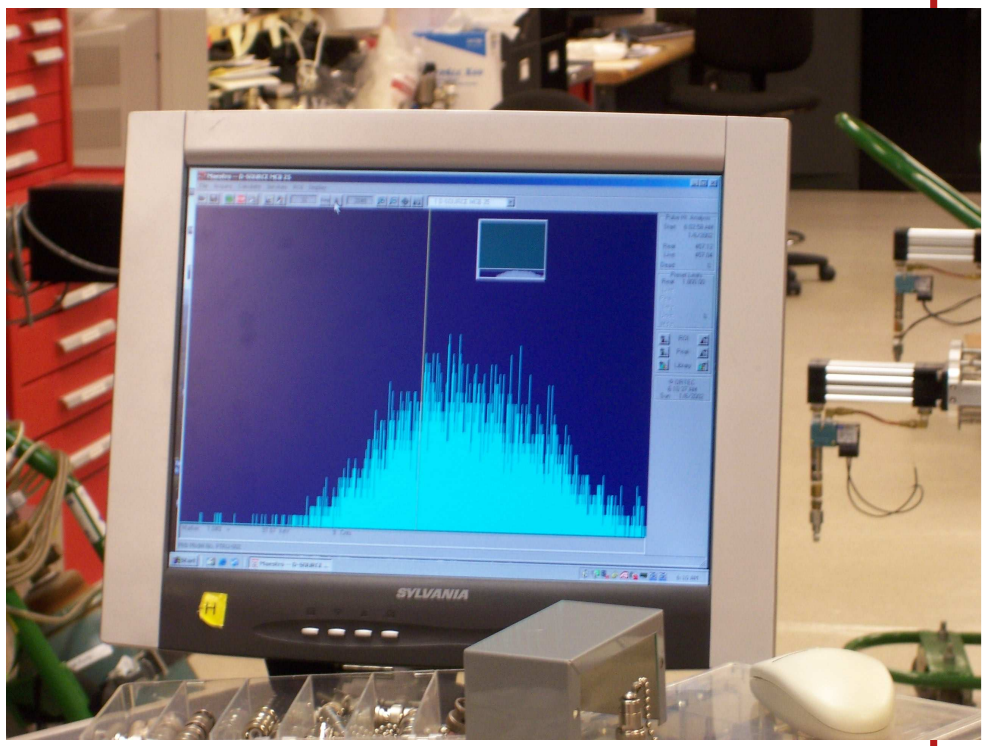
- **At the same time we start a TAC and stop it with ion signals**
- **Then we record the voltage of the TAC output signals and their count**





- **Measurement setup with additional equipment for test assembly**

- **Results:**
  - Assembly of the experiment through test assembly phase
  - Reliable detection of ion signals
  - Successful gating of ions
  - But noise problems persist
  - And resolution problems render TOF distributions meaningless



- **TOF experiment**
  - **Test assembly**
  - **CESR**
  - **ERL**
- **Test assembly (current state) for calibration of the detector by correlating measurements to known ion densities**
- **Installation on CESR in September**
- **Sometime thereafter installation on ERL gun**

- **Thanks to:**
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