TEGA EGA Ion Source Anomaly
Sol 4 TEGA Checkout II
5/29/2008

Overview

- TEGA was operating normally
  - Filament 0 selected and operating at 0.7A
  - Filament select 0 at 3.33V, Filament 1 select at 1.66V
  - Ionization energy at -91V
  - Emission current at 26uA
  - Trap current at 16uA
  - EGA input current at 320mA
  - Spectra were normal
- At T=5151, we opened the Sample valve, then closed it 1500 seconds later (at T=6663)
- At T=6785, we opened the Atmosphere valve, and closed it 1 second later
- At T=6938, we opened and closed the Atmosphere valve once again
  - The Emission current jumped up to 677uA*
  - Filament 0 current dropped to 0.4A (consistent with emission current too high)
  - Filament select 0 and Filament select 1 jumped to 6.65V*
  - Trap current jumped to 65uA*
  - EGA input current dropped to 285mA
  - Counts in the spectra went to 0 plus some noise
- At T=6971, we opened and closed the Atmosphere valve once again
  - All readings went back to normal

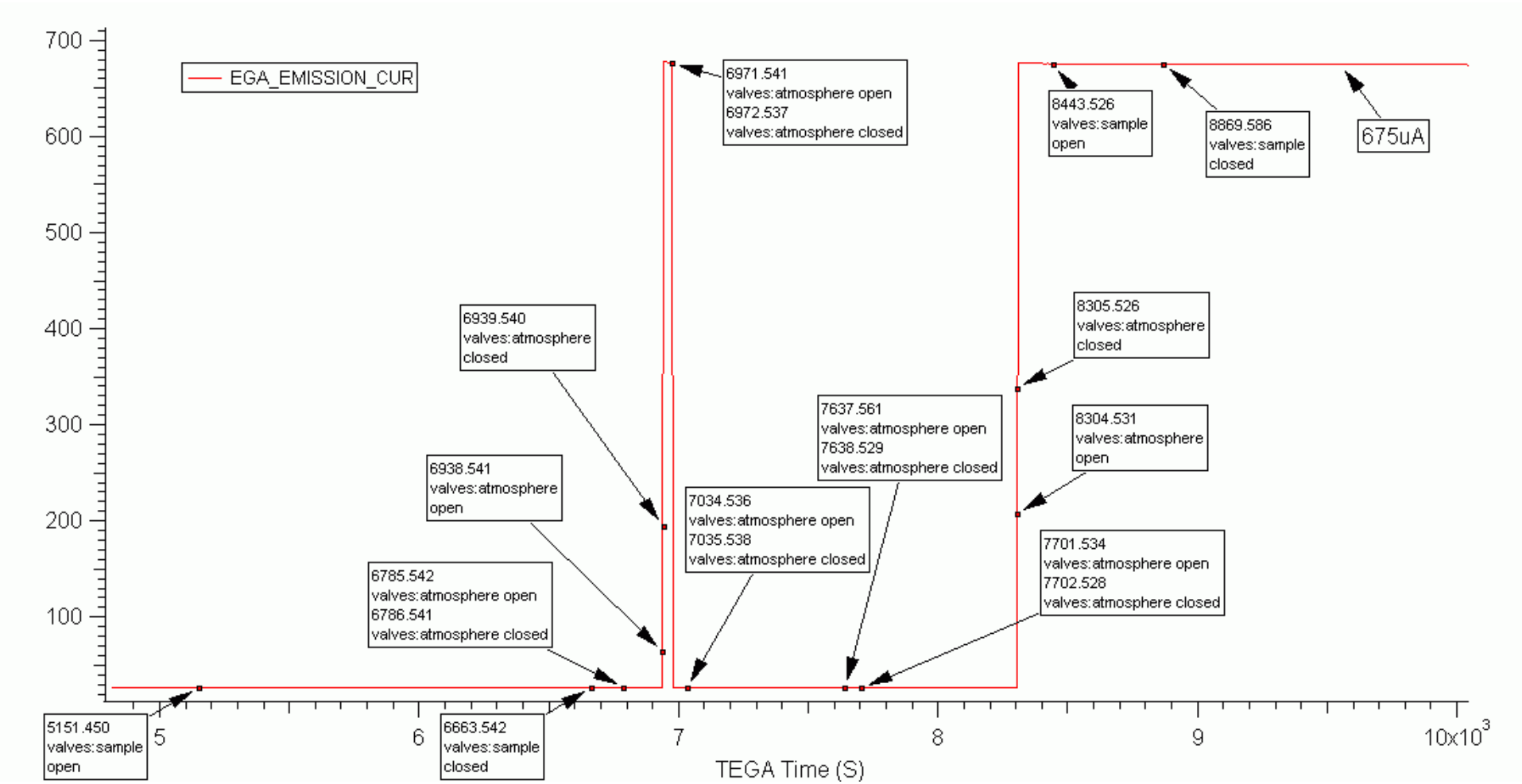
* - These numbers are physically impossible and indicate that the monitoring circuits are in a confused state.

Overview

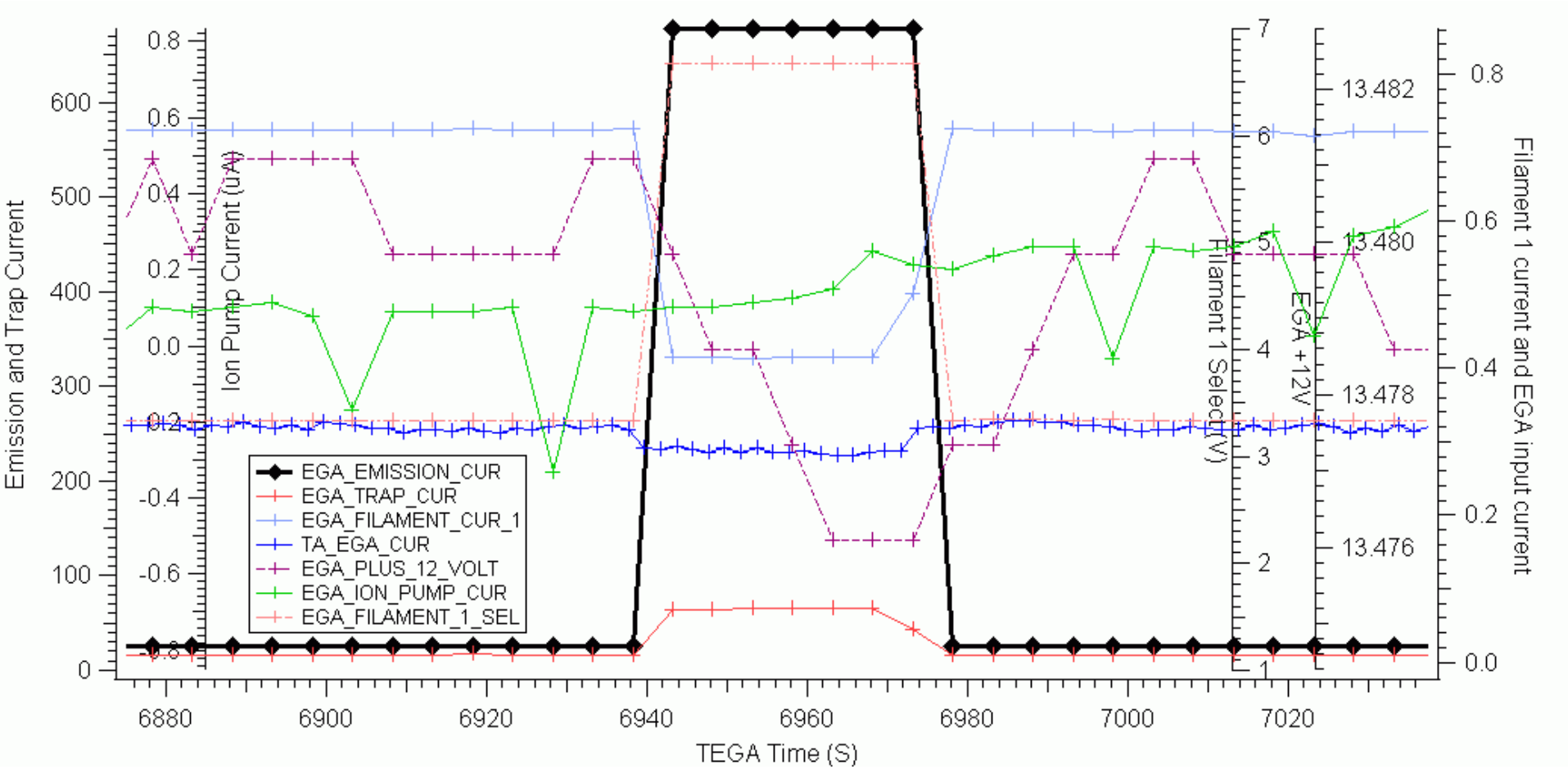
- TEGA operated normally for 22 minutes
  - During this time we opened and closed the atmosphere valve 3 more times
    - T=7034, 7637, and 7701
- At T=8304, we cycled the valve for the last time in the sequence
  - The Emission and trap currents, filament selects, filament 0 current, input current, and spectra went back to the abnormal values and stayed there
- We opened and closed the sample valve one more time with no effect.

Phoenix

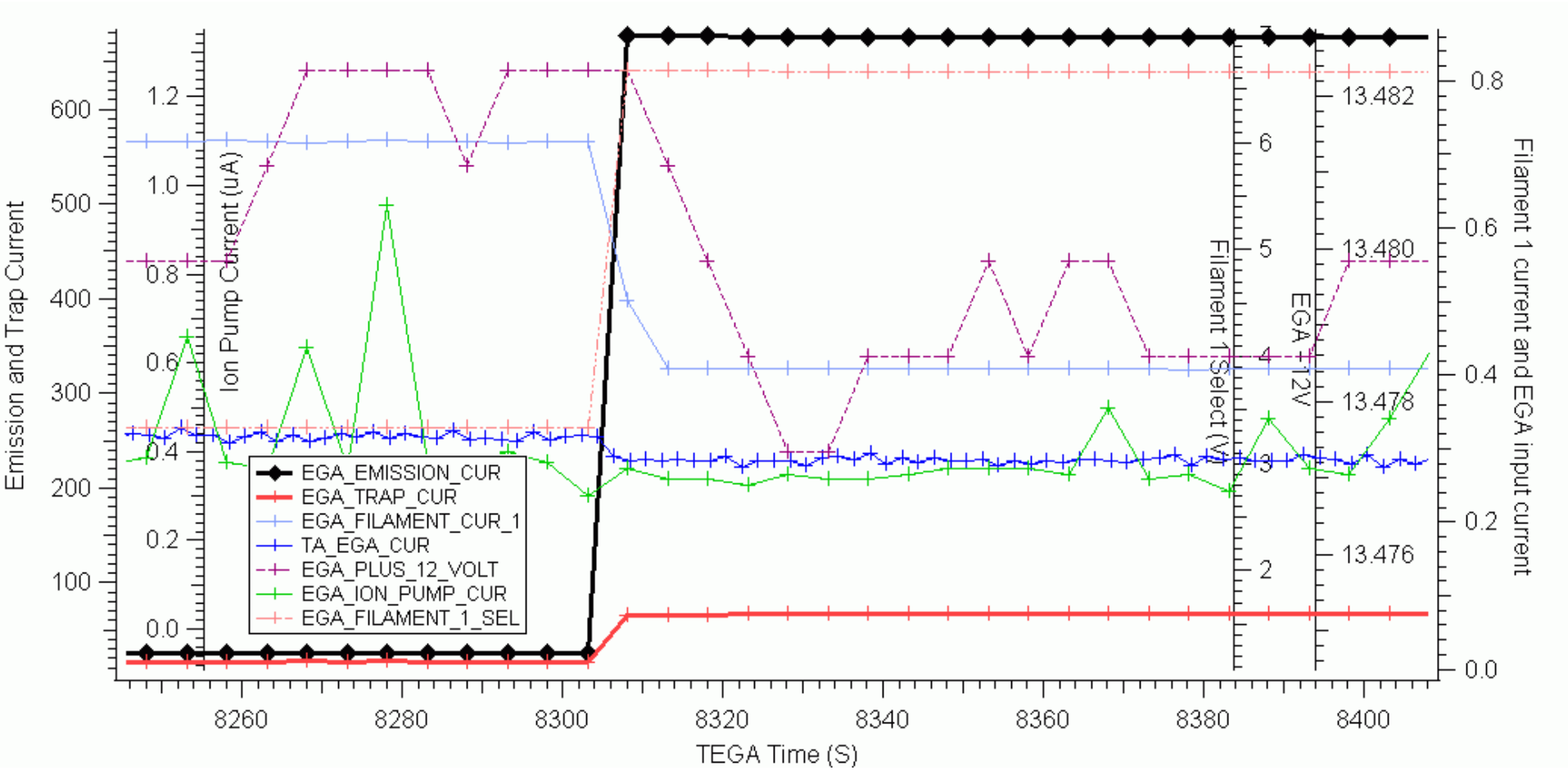
Valve Time Line



First Incorrect Readings



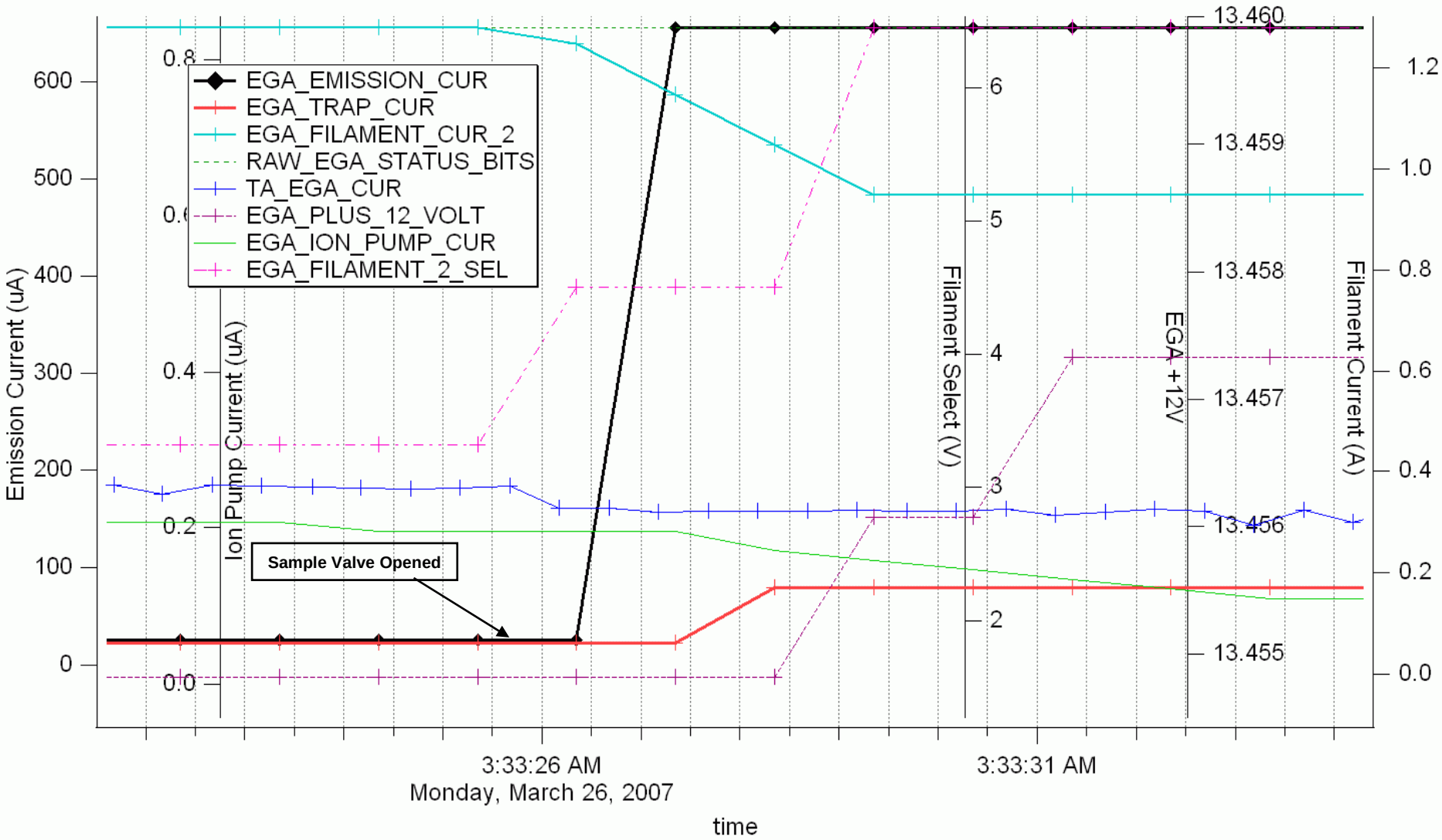
Second Incorrect Readings



3/26/2007 Pre-Delivery Failure

- This pattern was eerily familiar
- We pulled the data from the Ion Source short that happened right before delivery in March, 2007.
  - Instrument was operating normally
  - At 3:33:25 we opened the sample valve and the instrument exhibited the same symptoms as we see in the Sol 4 data
- We disassembled the instrument and found a 35 ohm path between filament 1 and the body of the ion source
- Partial disassembly of the ion source revealed a small piece of wire bridging between the filament and the pole piece of the magnet
  - There was also a lot of other debris in the ion source cavity that was cleaned out.
- We were unable at that time to inspect / clean filament 0

3/26/2007 Pre-Delivery Failure

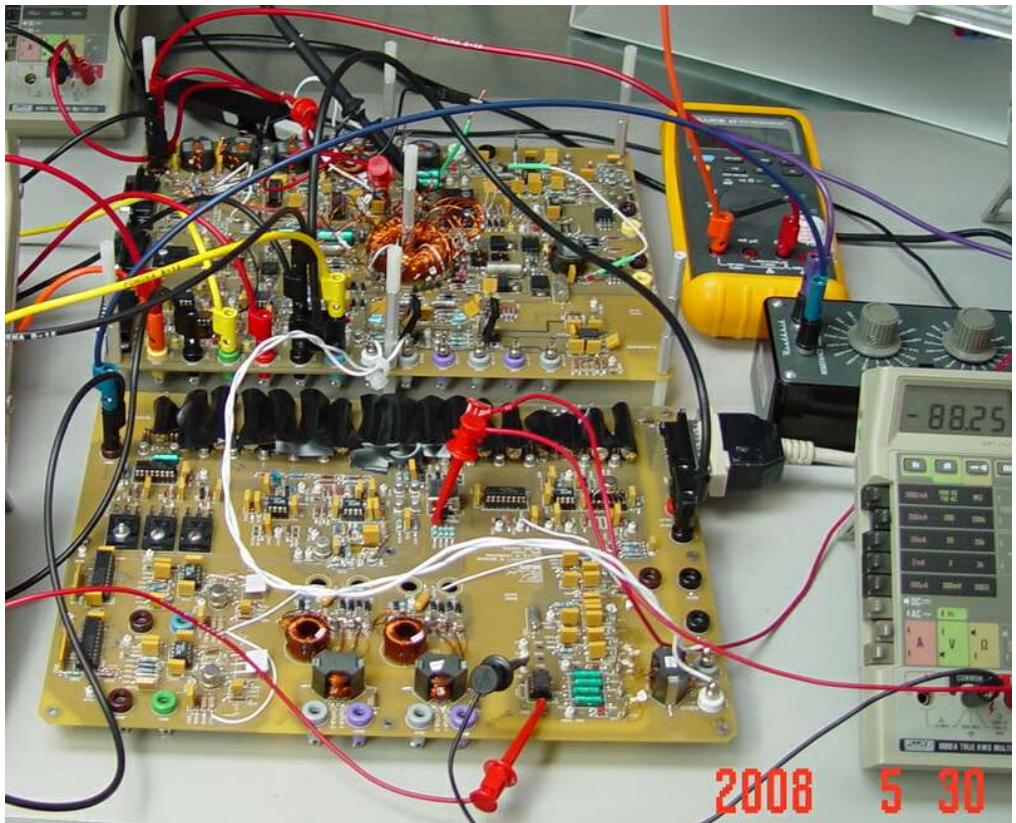


Note that we have changed the filament notation from {1, 2} to {0, 1} since this graph was made, so the filament that is showing the problem here Is now called filament 1. The two filaments have slightly different drive currents and efficiencies.

Breadboard Work

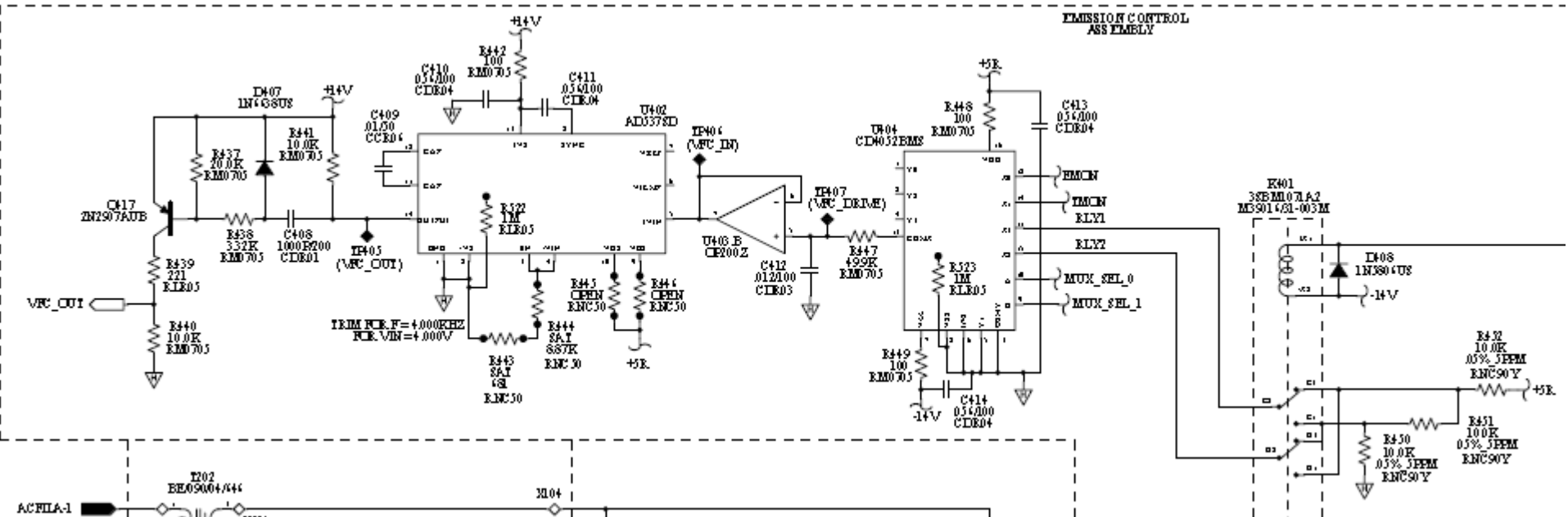
- **Steve Battel has a breadboard of the EGA electronics in his lab**
  - **Steve shorted filament 0 to the ion source body connection and saw the same symptoms as the Sol 4 and the March, 2007 anomalies.**
  - **From Steve's e-mailed report:**

"The important result is that I have been able to simulate the response of the emission control system on the FM. *When the short is introduced, the filament goes to an OFF state with a corresponding drop in the FIL curmon as well as a drop in the instrument power. The numbers are not an exact match since the instrument load and filament load are not identical to flight. However, the profile is a match. *Thus, at this point, we have a match for all of the observed characteristics of the FM problem."



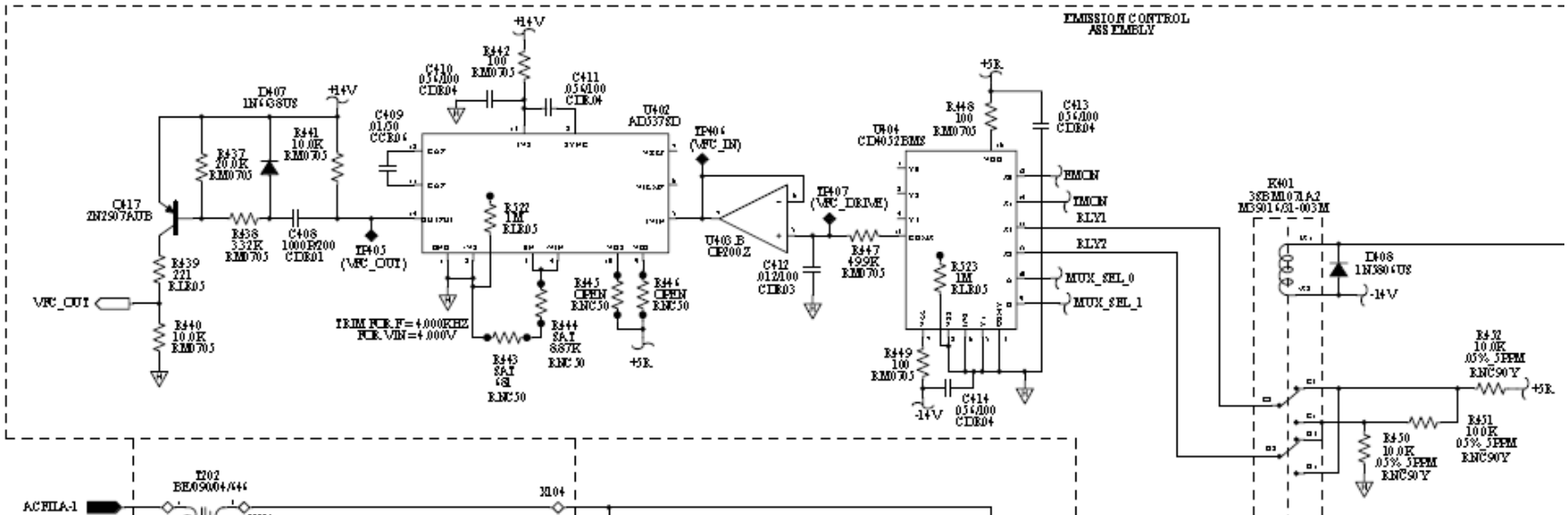
Other Possible Causes?

- **Electronics Failures**
  - **Power Supplies?**
    - **All other telemetry from the PECM is normal**
      - **Sweep Voltage**
      - **Ion Pump Voltage**
      - **CEM power supply**
      - **Other low voltage supplies**
    - **All of these are derived from the same primary circuits as the emission supply**
  - **Monitor Circuit Failure?**
    - **Emission Current, Trap Current, and the two Filament Select lines all run through a path that is unique to those 4 signals**
    - **However, if this was just a monitoring issue, the counts in the spectrum would not have gone to 0**



Analysis

- This leaves us with the conclusion that SOMETHING is disturbing both the operation of the monitoring circuit AND the actual production of ions.
- A current shunt from the filament to the ion source body will indeed cause both of these symptoms.
  - The -91 volts normally on the active filament will be pulled to something near zero
    - This will cut off the electron beam, cutting off the ion beam
  - the EMON input to the 4052B multiplexer will go to the +14V rail
    - This will cause a large offset on all the other channels consistent with what we are seeing



Moving Forward

- **We have 2 filaments**
  - **Filament 0 is the primary, filament 1 is the backup**
  - **The backup filament is used as the other end of the ion generator**
  - **Primary filament is at -91V and emits electrons**
  - **Electrons are accelerated to the secondary filament which is kept at +24V**
- **The ion source will operate *almost* normally if the secondary filament is at 0V instead of +24.**
  - **John believes good enough to do good science**
- **Shorting out the 24V, while not desirable, will not harm the instrument.**
  - **From Steve Battel:**

"I have completed the investigation with the upgraded breadboard. The upgrade to compensate for the opto-coupler gain makes a tremendous difference. Unit is stable in the proposed FIL2 configuration and properly regulates despite an induced short in the test setup. The reference rises from 5.001 volts to 5.002 volts and has greater than a margin of 2X against losing regulation given the backfeed current . Have run in the shorted mode for a fair bit of time and can find no hot spots or surprises. Expect the EMON to read ~1350 Hz with the trap shorted. TMON will read ~4500 Hz with the position monitors reading around 6400 Hz. Note that the relay switch must be inferred from the change in EMON and TMON since the position readings will be off scale."

- **We propose that we switch to the backup filament and collect a few minutes of data to:**
  - **A) assess the quality of data while operating in this mode**
  - **B) see if the short has gone away due to thermal contraction of filament 0**