UV Illumination Studies at Trinity University

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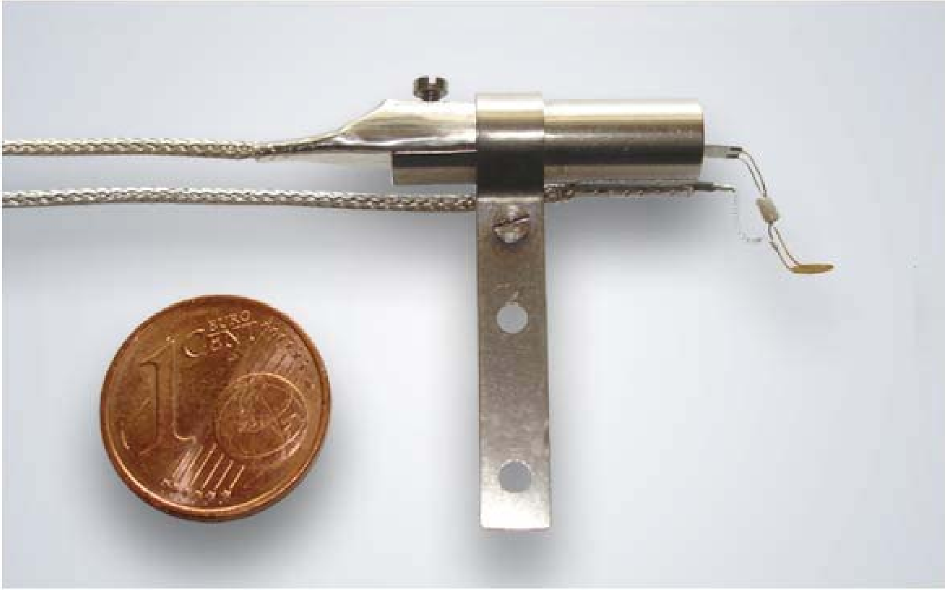
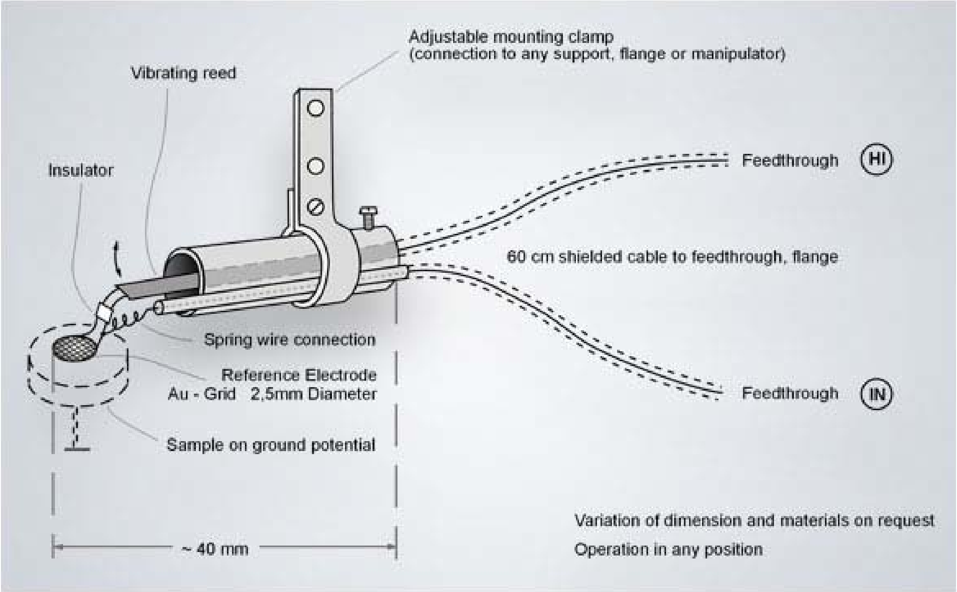
2007 Workshop on Charging Issues
July 27, 2007

- Calibration of Besocke Kelvin probe
- Discharge rates versus UV intensity, wavelength
- Addendum: International Cosmic Ray Conference

Besocke Kelvin Probe





- Vacuum-compatible probe from Besocke delta phi GmbH
- Probe + preamplifier = $7,100
- Modulates probe electrode position with PZT
- Reported sensitivity of 0.1 mV

Probe Calibration

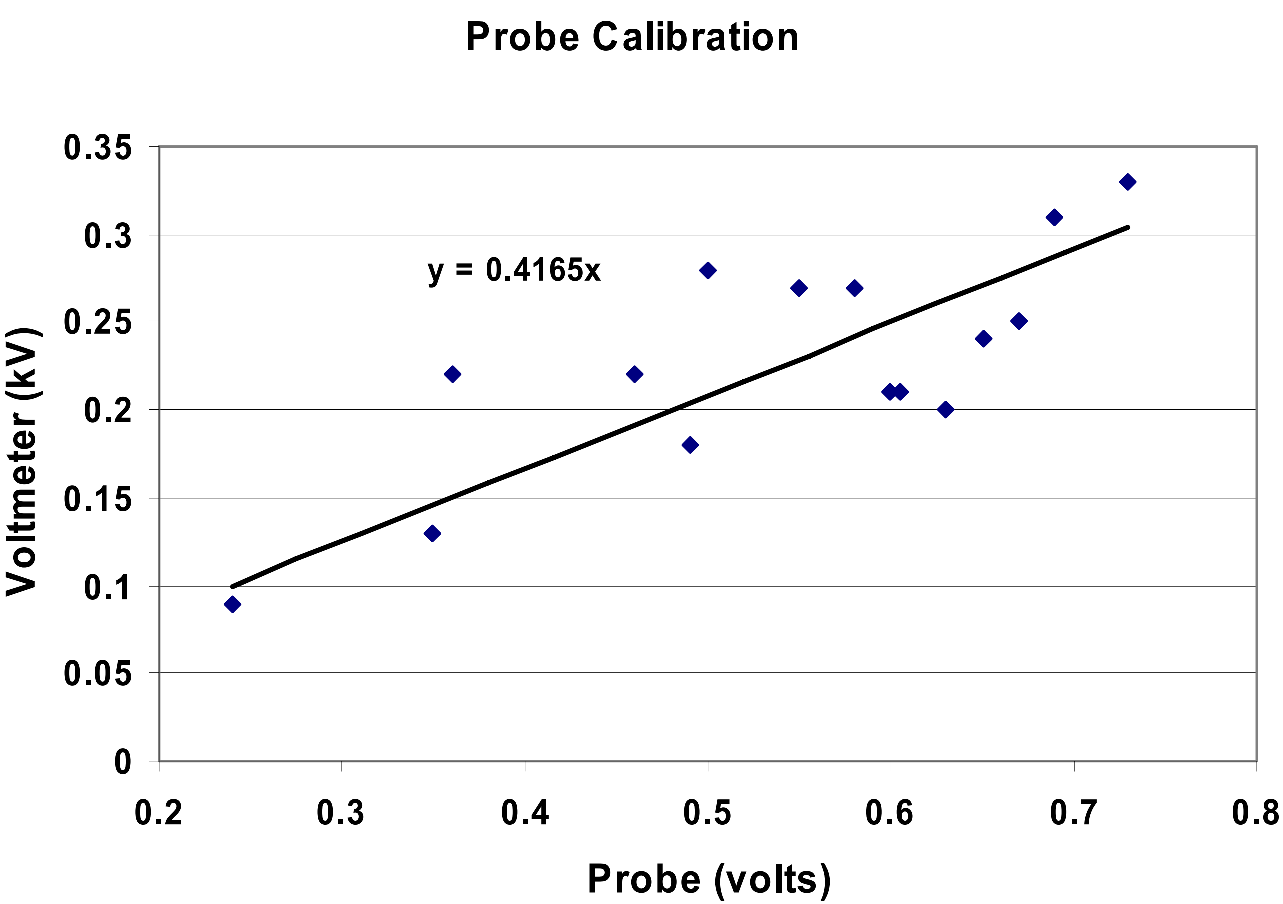
- Rub acrylic surface with viton O-ring
- Measure with probe and surface DC voltmeter (shown at right)
- Convert voltmeter reading to charge density via

$$\sigma = \frac{V_{meas}}{1kV} \frac{5.04 \times 10^{-7} C/m^2}{1 + (2L/D)^2}$$

L = meter-to-sample distance (2.5cm),
D = diameter of sample (7.6cm)

- Find charge corresponding to probe noise level

Calibration Results



For the fit shown, a probe signal of 1 volt

= 10^{-7} C/m^2

= 8 × 10^7 e$^-$/cm^2

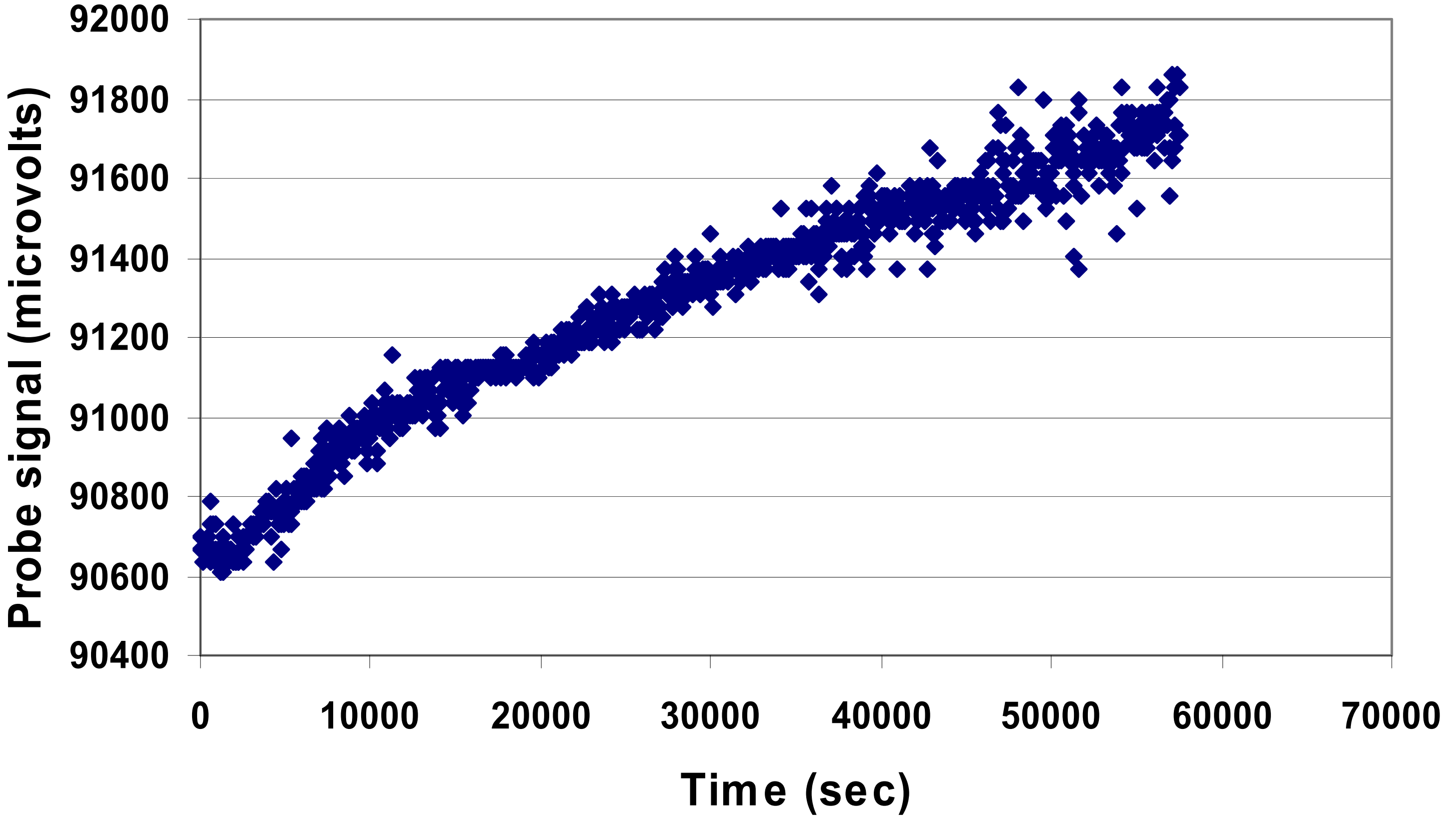
Since the probe noise level is measured to be +/- 0.1 mV, sensitivity

= 10^{-11} C/m^2

= 8 × 10^3 e$^-$/cm^2

Sensitive to probe-to-sample separation

Overnight Charging?

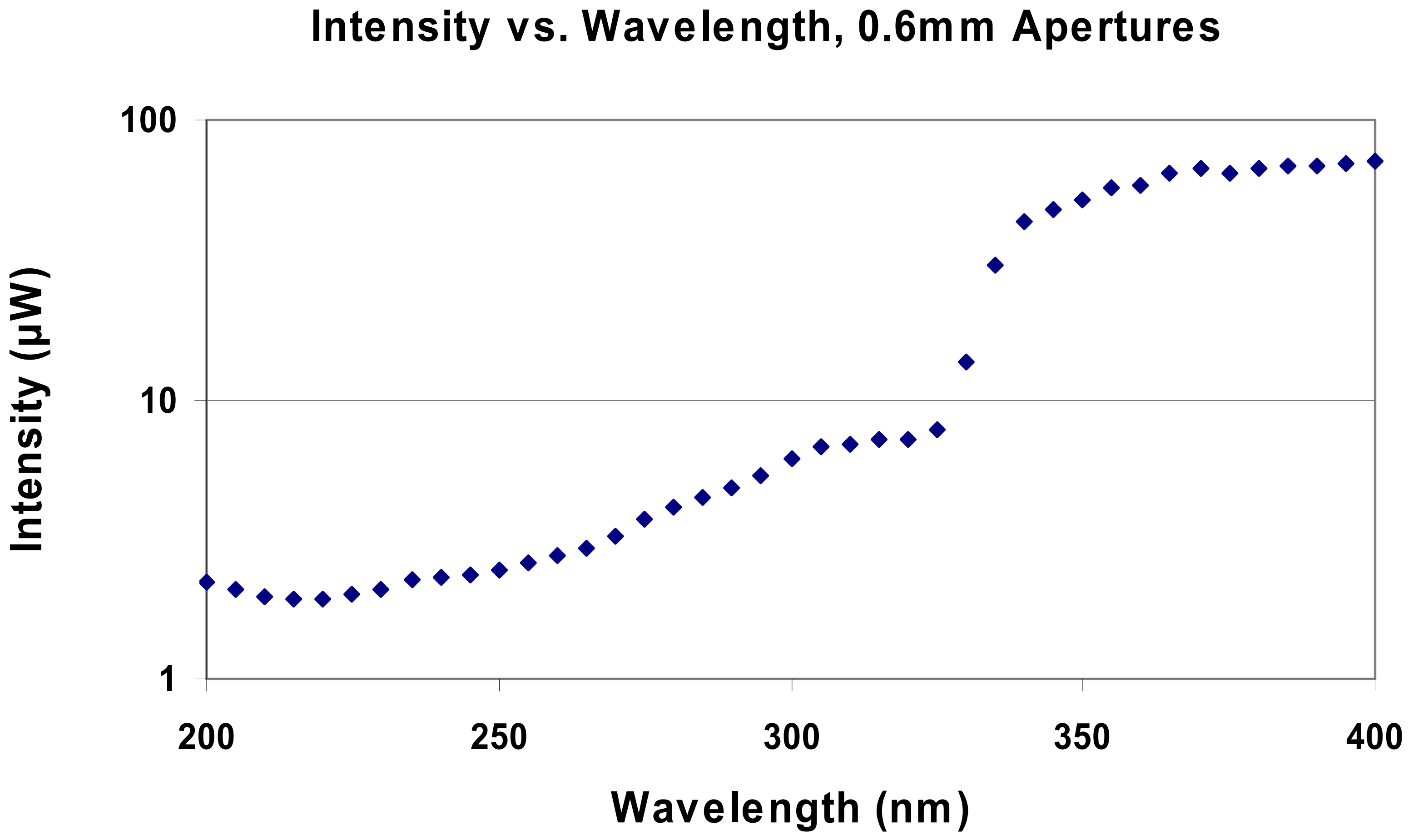


- Equivalent to ~ 10^5 e^-/cm^2/day (sign known through UV test)
- Reduced when probe is powered off

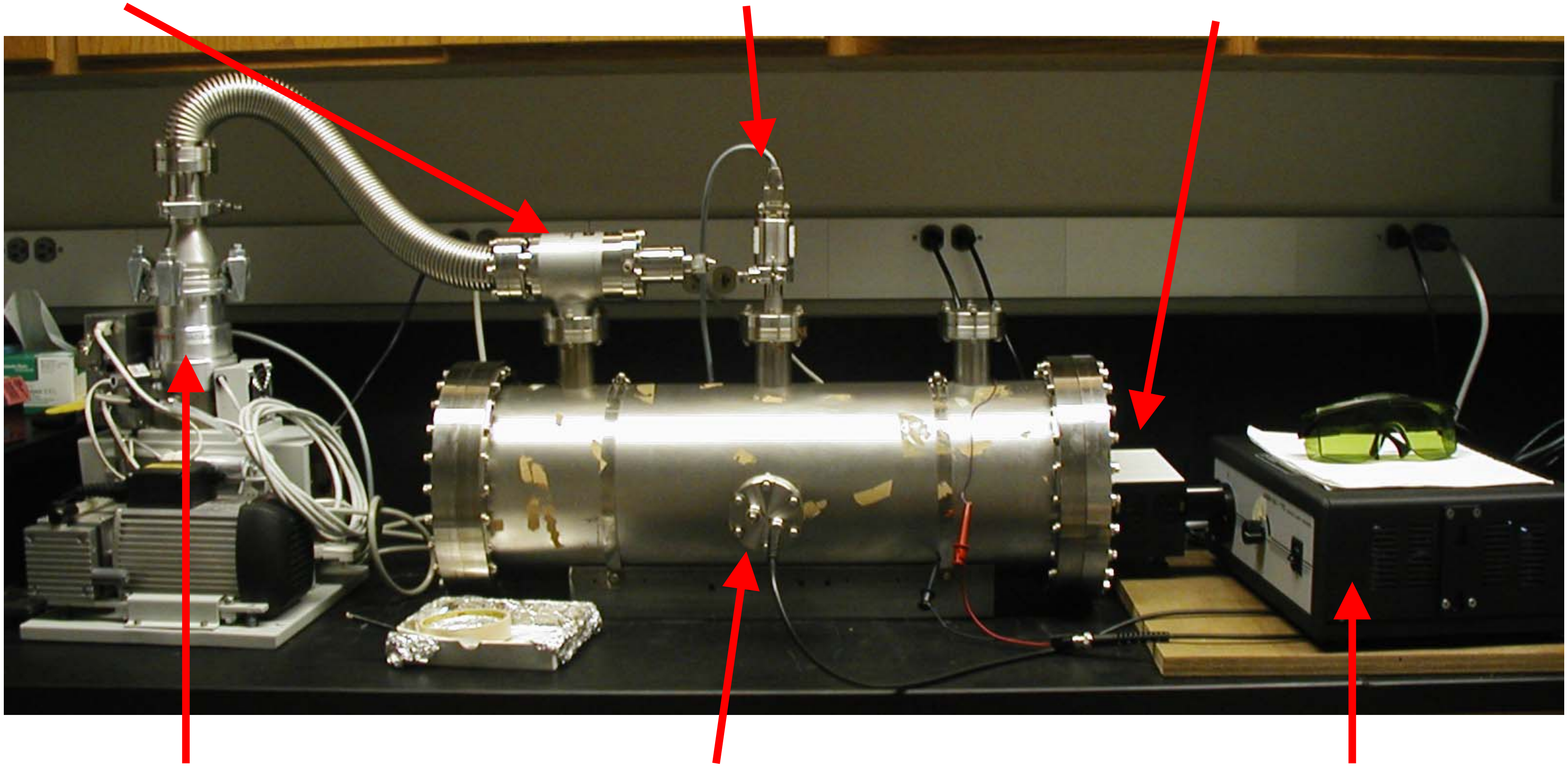
UV Light Source

- 175W broadband Xenon lamp, 200nm – 2,200nm
- 2400 lines/mm monochromator grating, 180nm-680nm range
- Intensity control through lamp knob, monochromator aperture

UV Intensity Spectrum



Experimental Setup

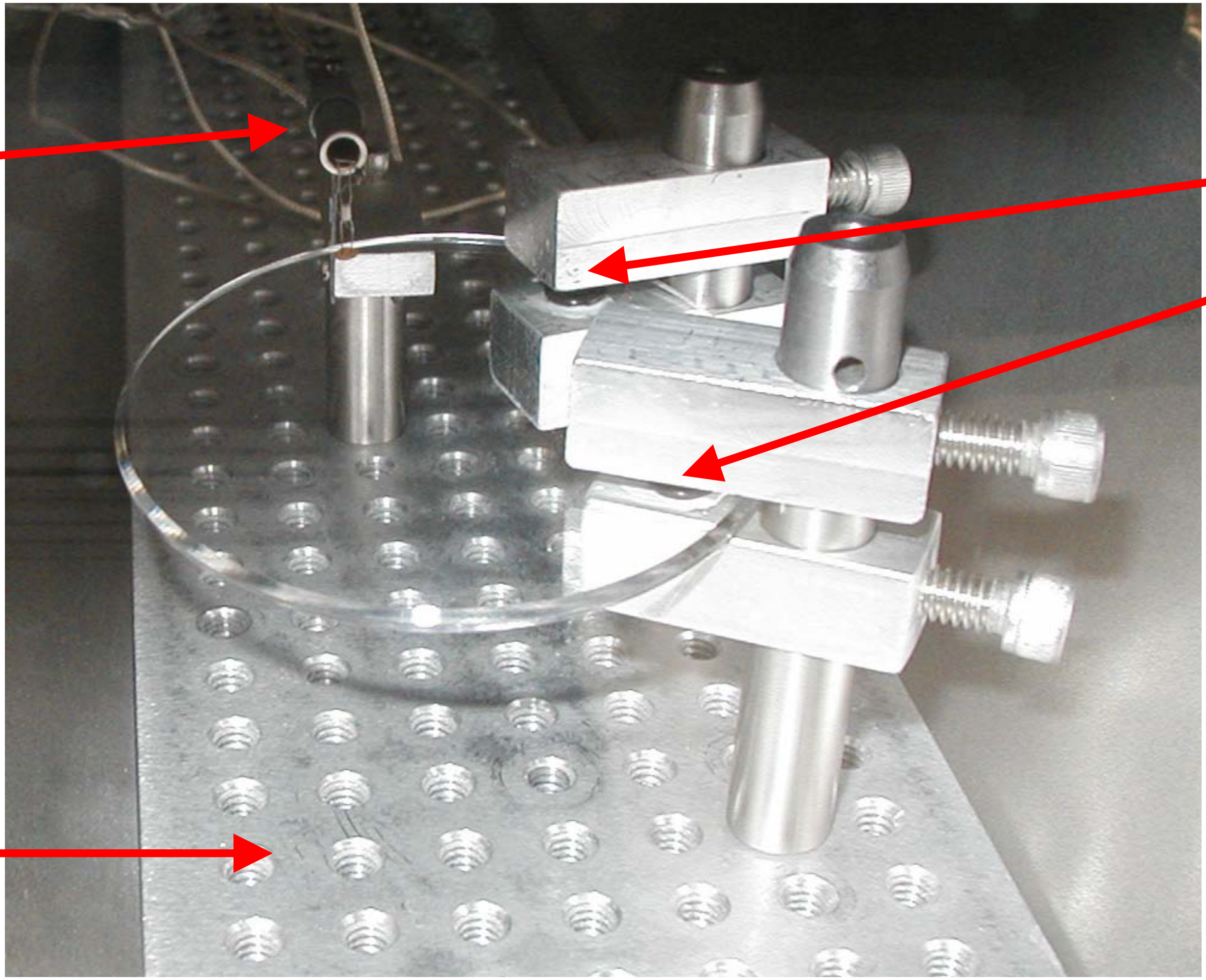


Experimental Setup (cont.)

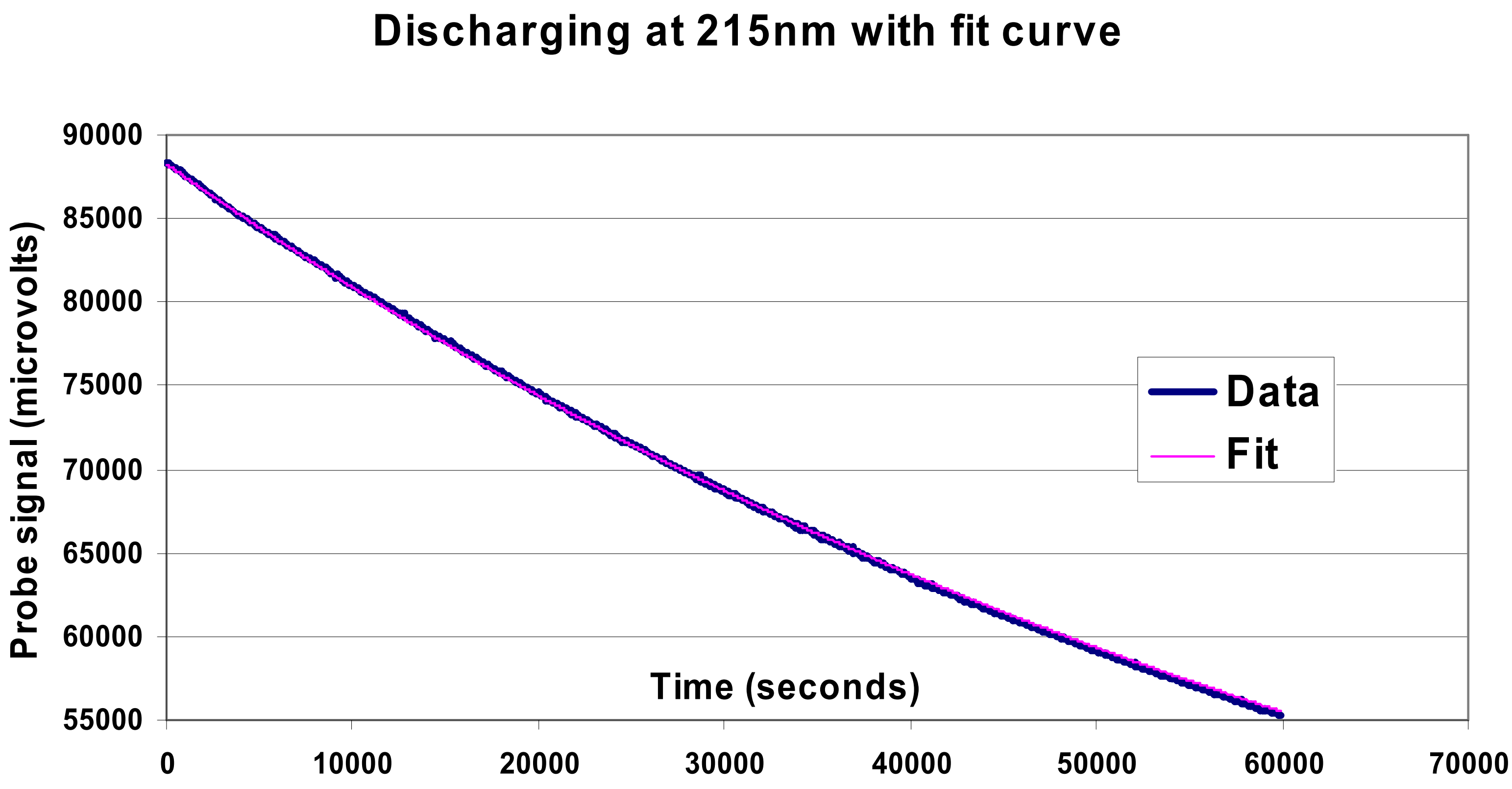
Besocke probe

Clamps (with viton O-rings)

Removable table

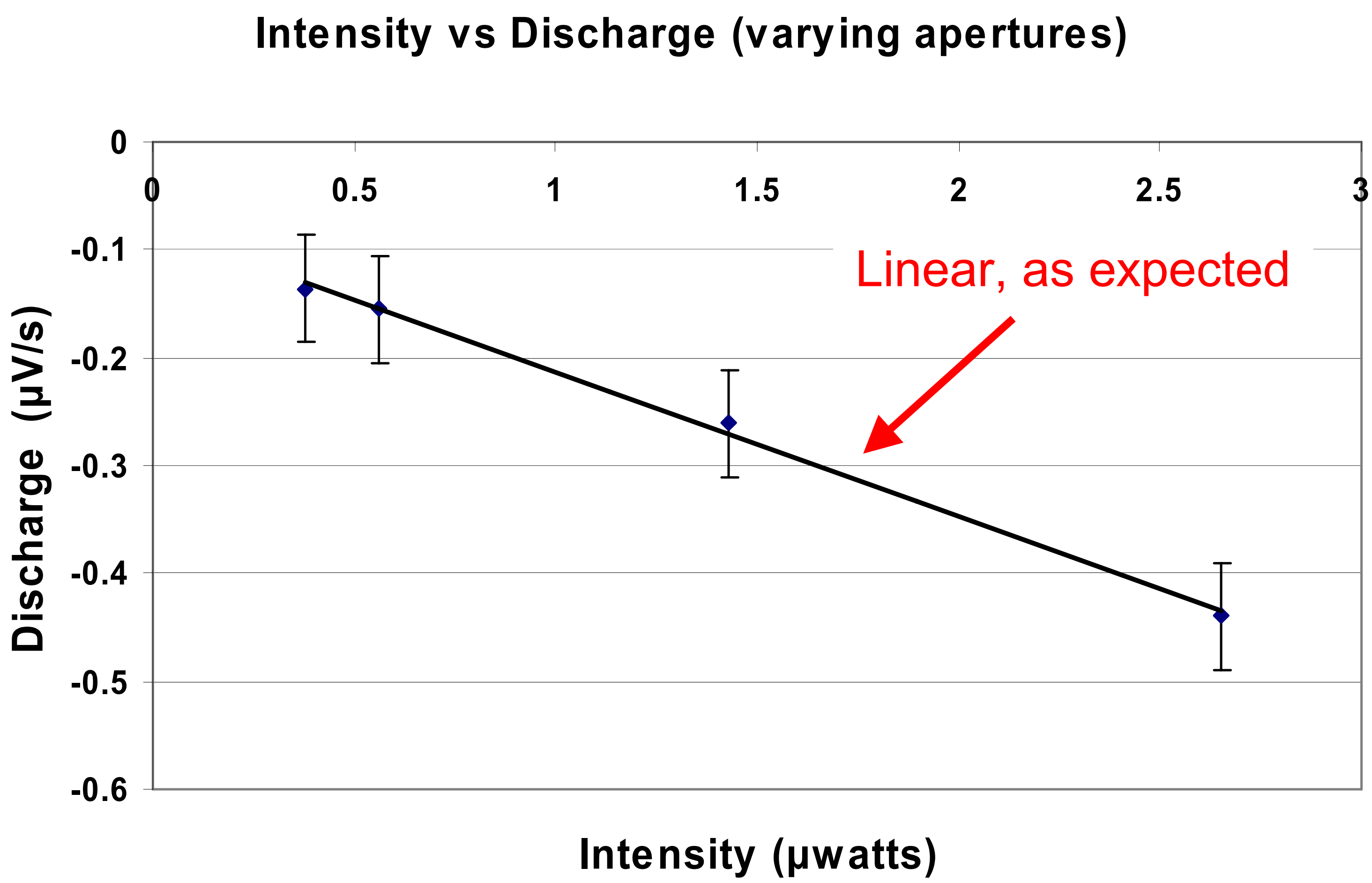


UV Discharge

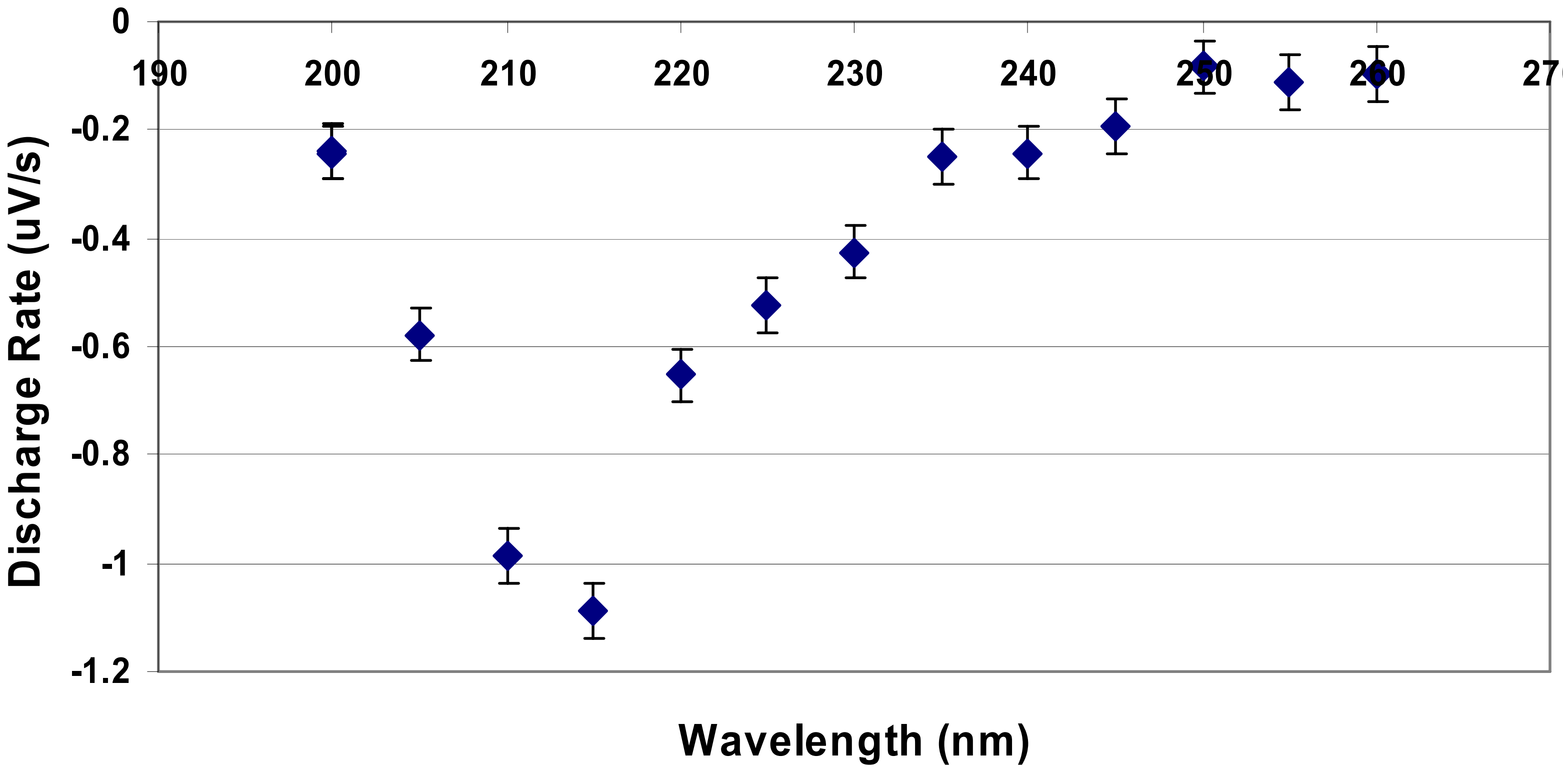


- Exp. fit implies linear relationship between charge level and discharge rate
- Gives correction for measurements taken at different charge levels

Discharge vs. Intensity

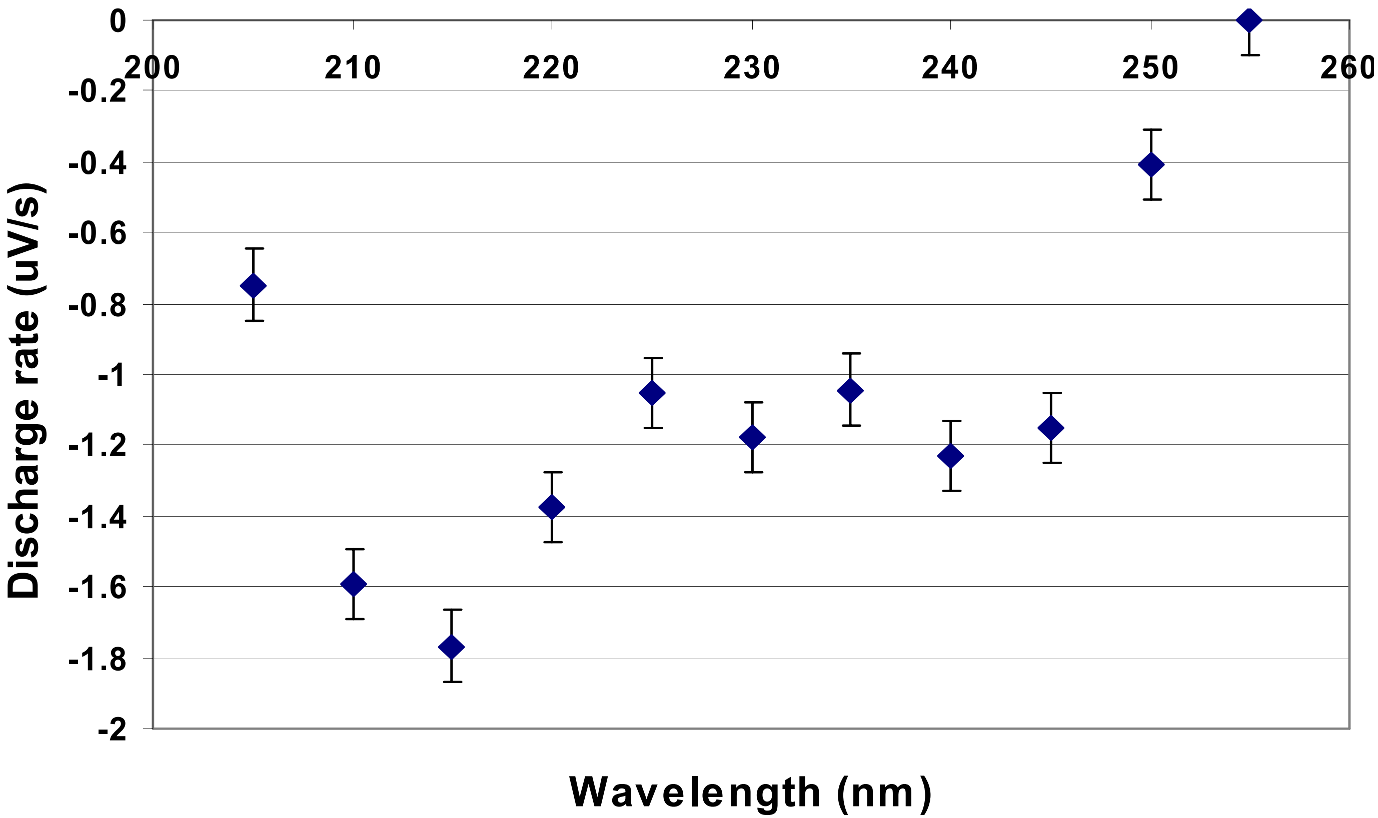


Discharge vs. λ, Uncoated



- Corrected for charge level, source intensity, viewport transmission
- Peak response at 215nm, surprisingly low at 255nm

Discharge vs. λ, Coated

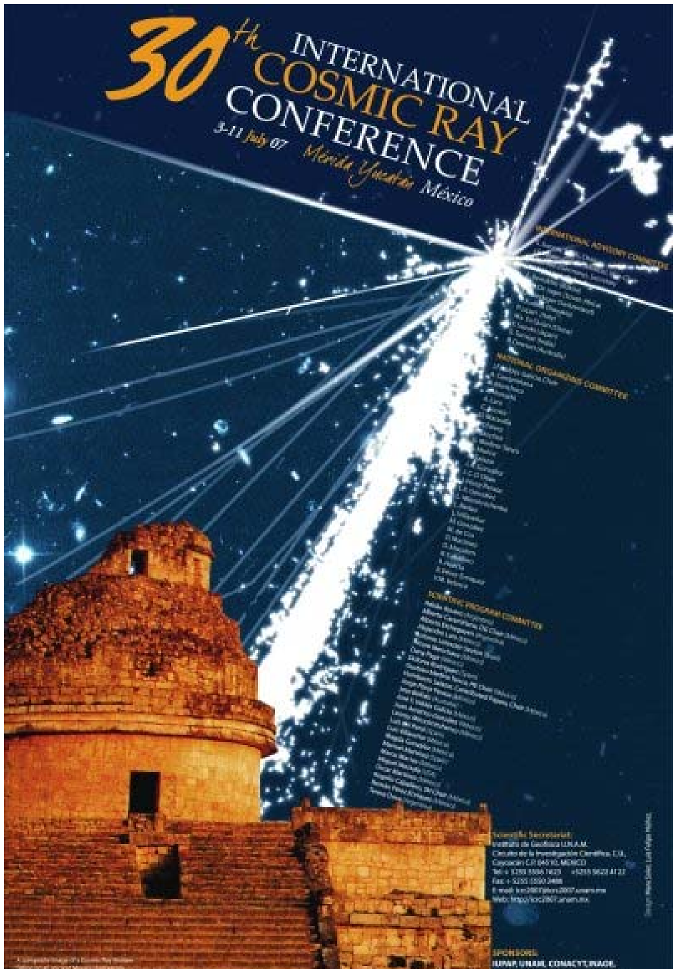


- Greater response in 225-245nm range
- Concern – same results for both sides of optic?

Future Work

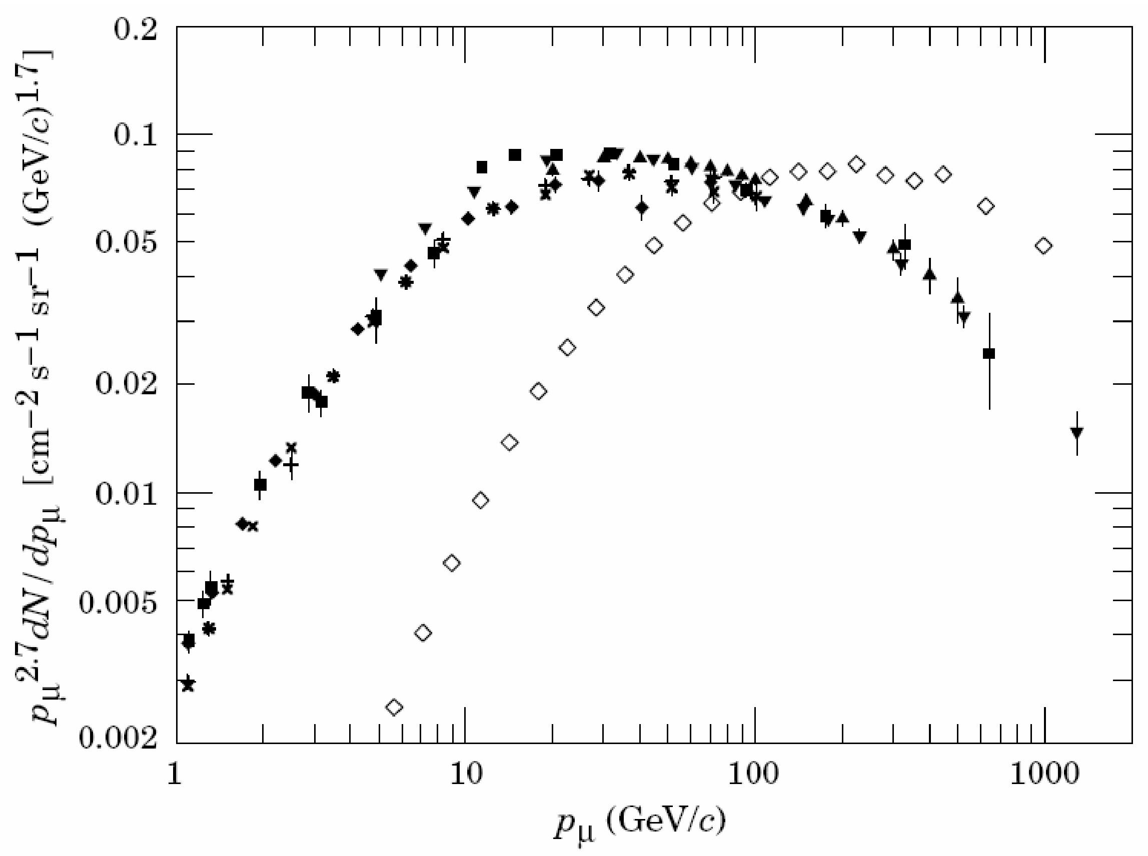
- Measure discharge rate, relaxation time, and spatial variation of charge for:
  - » Different optical coatings
  - » Different cleaning/handling techniques
- Testbed for other ideas as they come along

International Cosmic Ray Conference



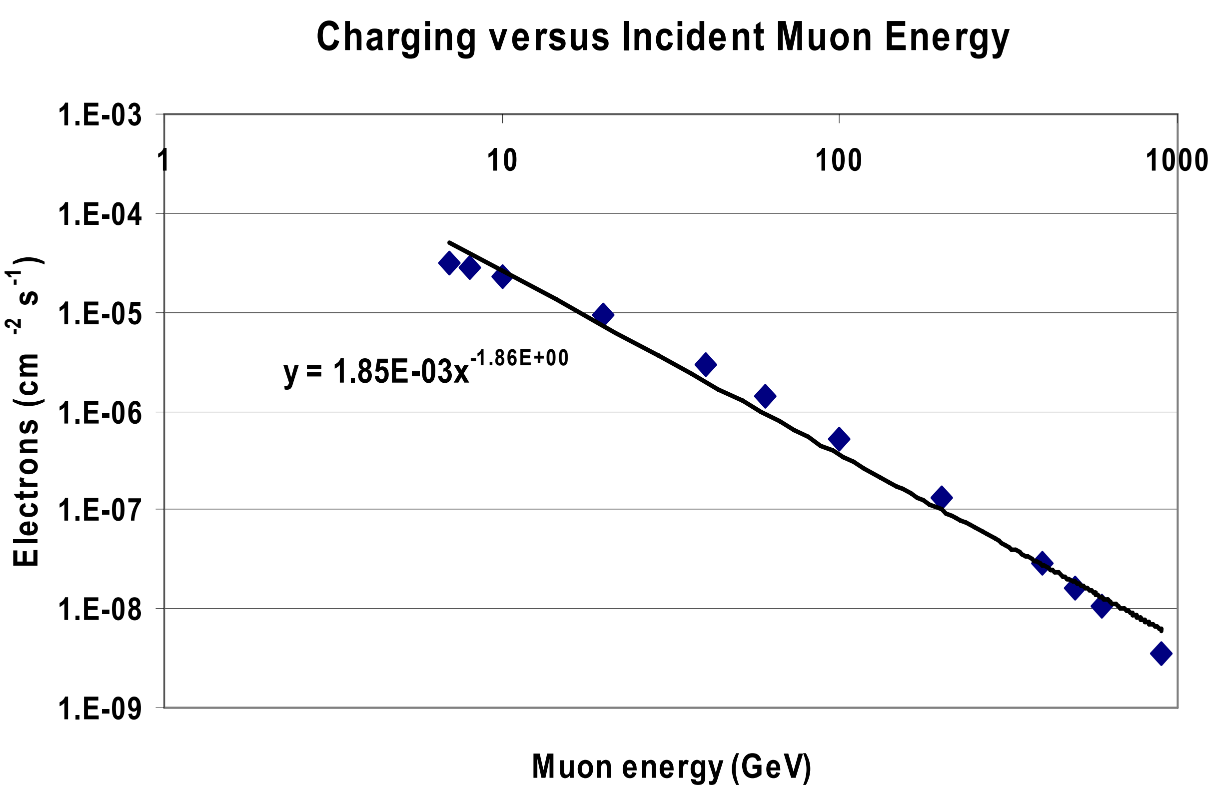
- Charging due to cosmic rays “likely”
- GEANT model of vacuum chamber would be useful
- Until then, rough calculation of charging rate can be attempted as follows:
  - » Determine muon flux at ground (given in 2006 Review of Particle Properties)
  - » Measure thickness of vacuum chamber
  - » Estimate energy loss in iron (plots given in muon detector design documents)
  - » Convert to electrons via equation given in Braginsky et.al., Phys. Lett. **A350**, 1-4 (2006).
  - » Integrate to find total rate

Muon Flux at Ground



- Muon flux has $\cos^2\theta$ dependence
- Energy distribution also depends on angle:
  - » Solid points = 0°
  - » Empty points = 75°
- Gross assumption – integrate over solid angle using distribution at zero degrees
  - » Not so bad – most muons at low angles

Rough Charging Estimate



- Assume muon passes through 1cm of iron
- Fractional energy transfer ~ 0.01
- Lower cutoff energy = $E_{cr}/0.01$ = 2.07 GeV
- Integration yields a charging rate of 3 × 10^3 e^-/cm^2/month, 30 times less than Moscow State meas.