Charge Measurements at LASTI

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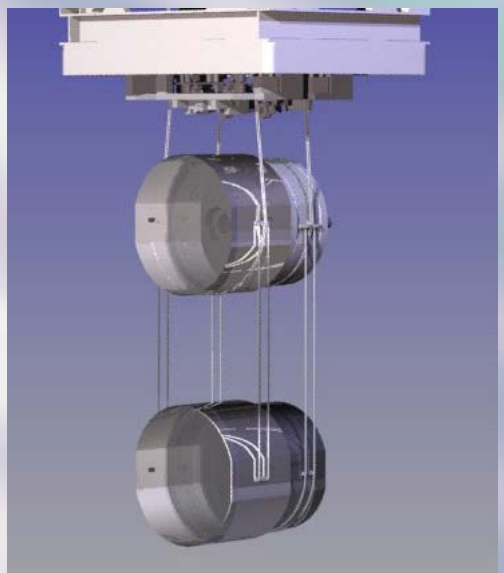
Joint IS Session on Charging

March 18, 2010

G1000208-v1

Electro Static Drive

- Gold pattern on compensation plate
- Apply control forces to test mass with voltage
  - DC bias voltage applied to allow for push and pull
  - Force between test mass and compensation plate



- Use to monitor charge on rear face of test mass
- Most sensitive to charge directly facing electrodes

LIGO

Method

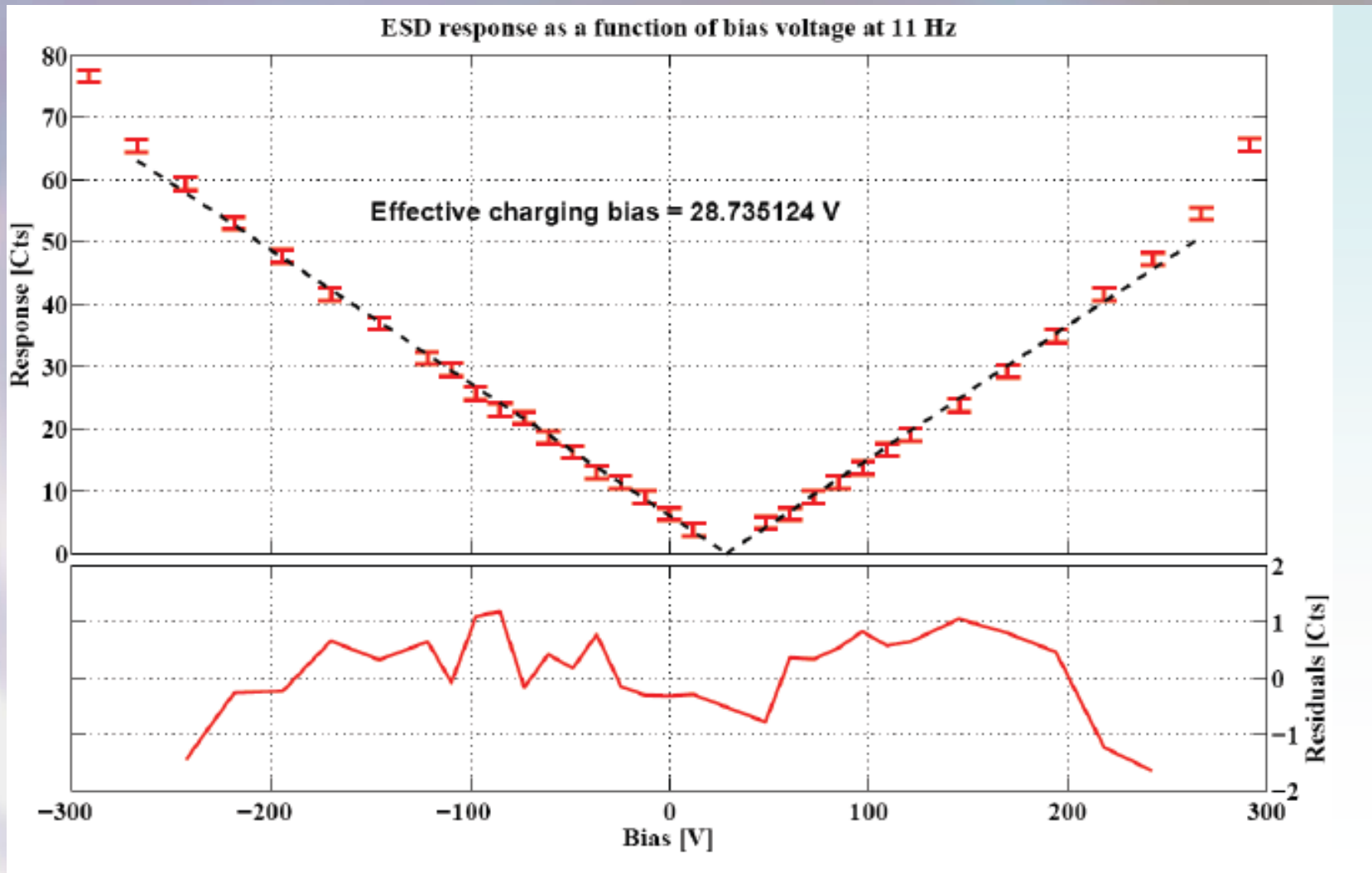
- Follows Hewitson *et al*, CQG **24** (2007) 6379
- Charge on optic introduces a bias to transfer function between ESD voltage and optic position

  $X(\omega) = 2A/\omega^2 (V_{bias} + \beta) V_{act}$

  β is proportional to charge on optic
- Will see zero in X/V when $V_{bias} = -\beta$
  - Will be $V_{bias} = 0$ when optic is not charged
- Bias voltage scanned and X/V measured

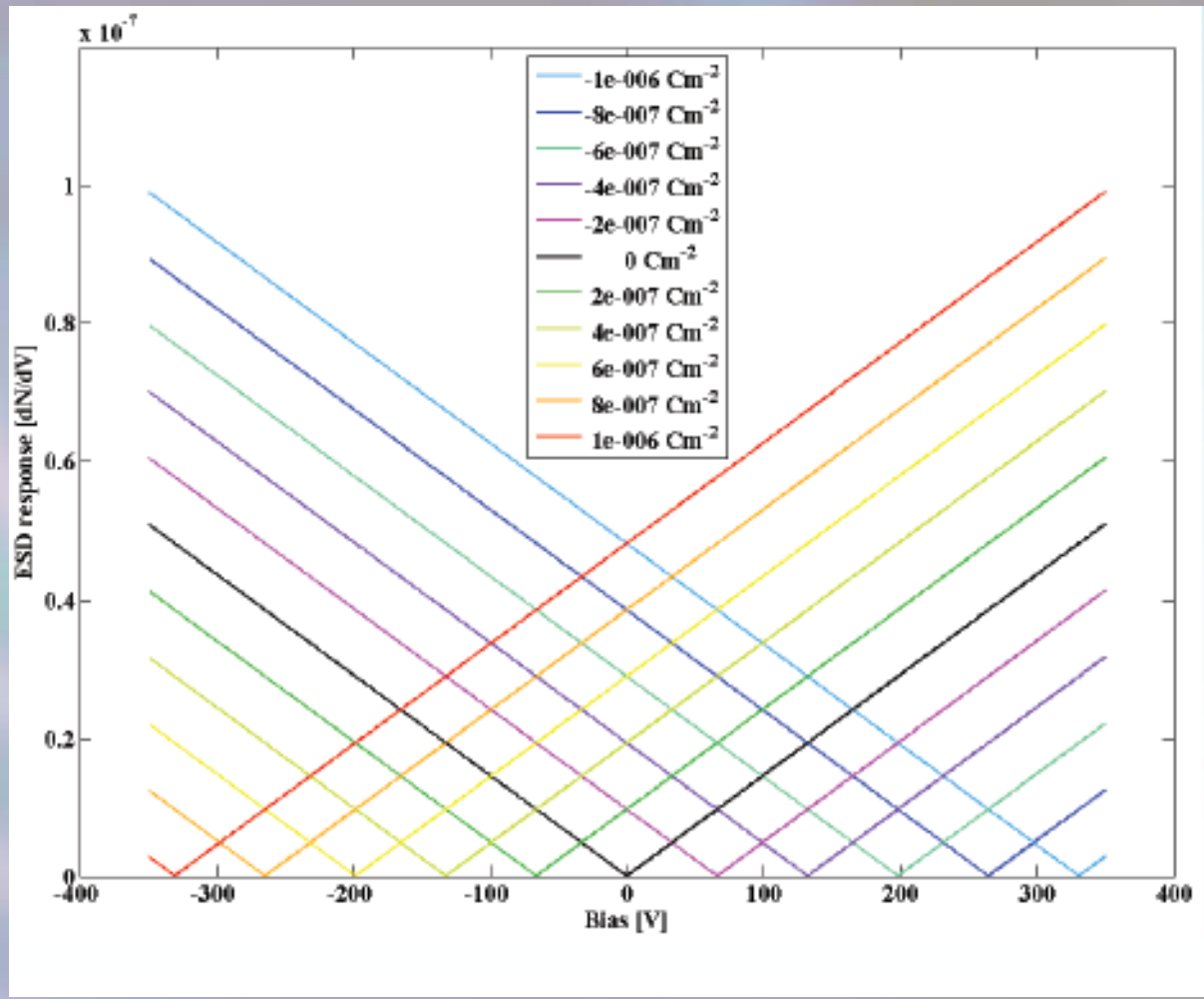
LIGO

Results



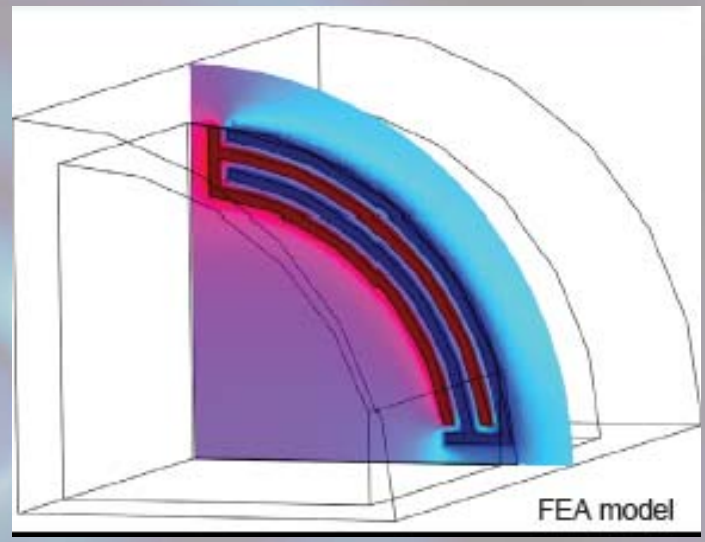
Modeling

- To convert bias volts to charge on optic, need a model
- Use uniform charge on back face
- 3.6 X 10^9 V/C

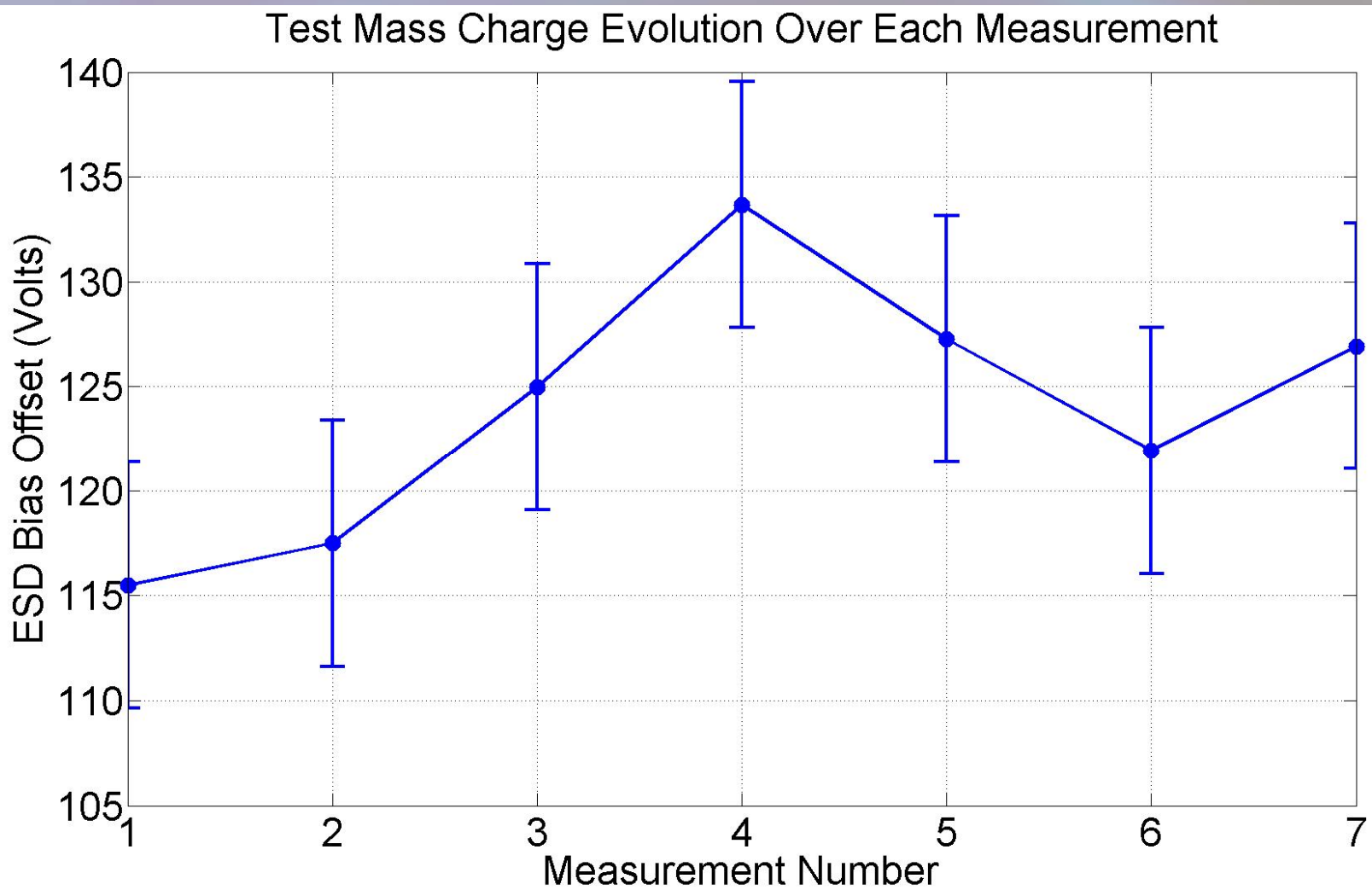


Charge Distribution

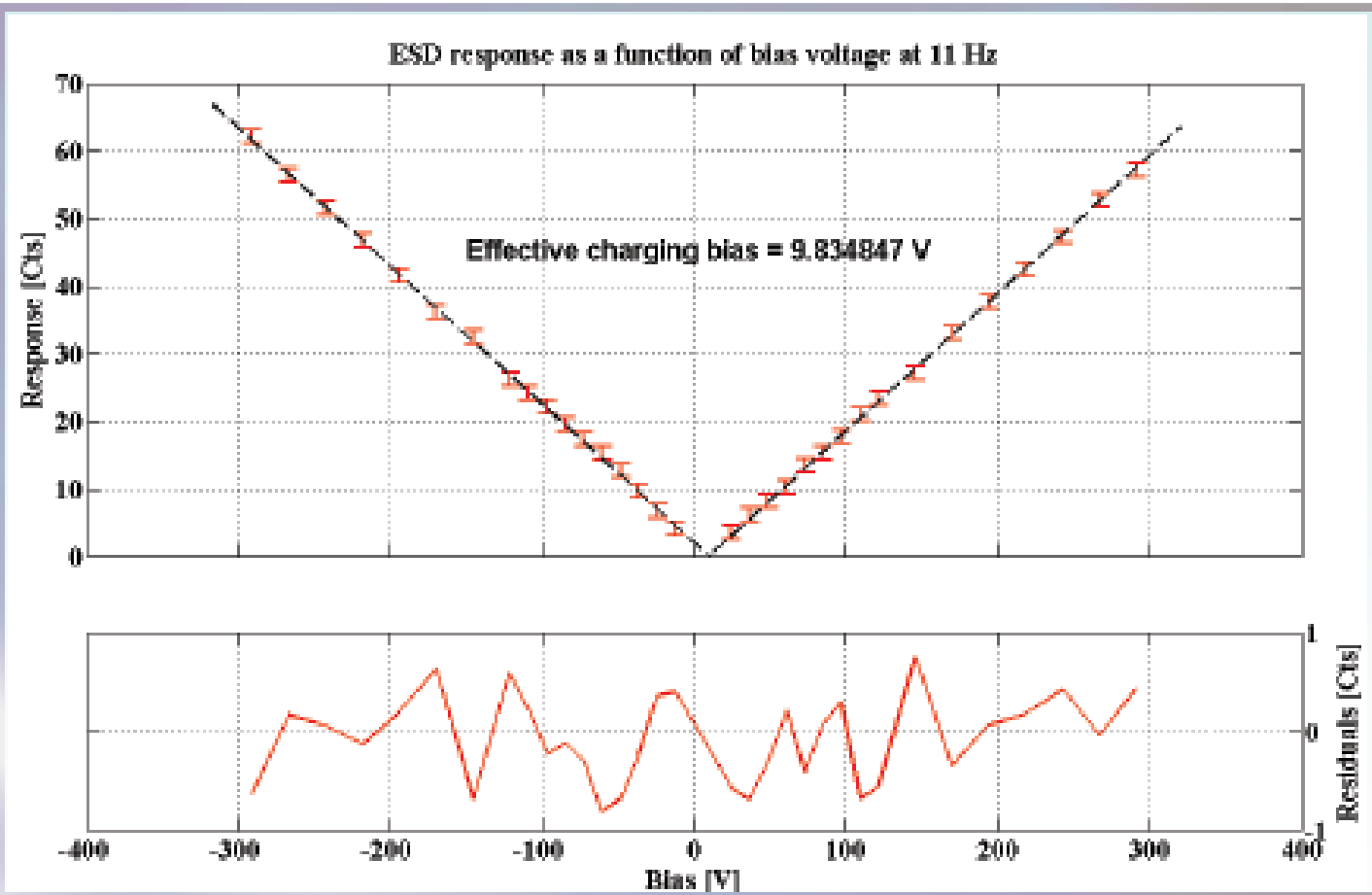
Quadrants	Charge
All	-2.7 nC
Q1	-8.4 nC
Q2	-2.4 nC
Q3	-0.17 nC
Q4	?
All, with HV on during pumpdown	-31 nC



Uncertainty in Measurement

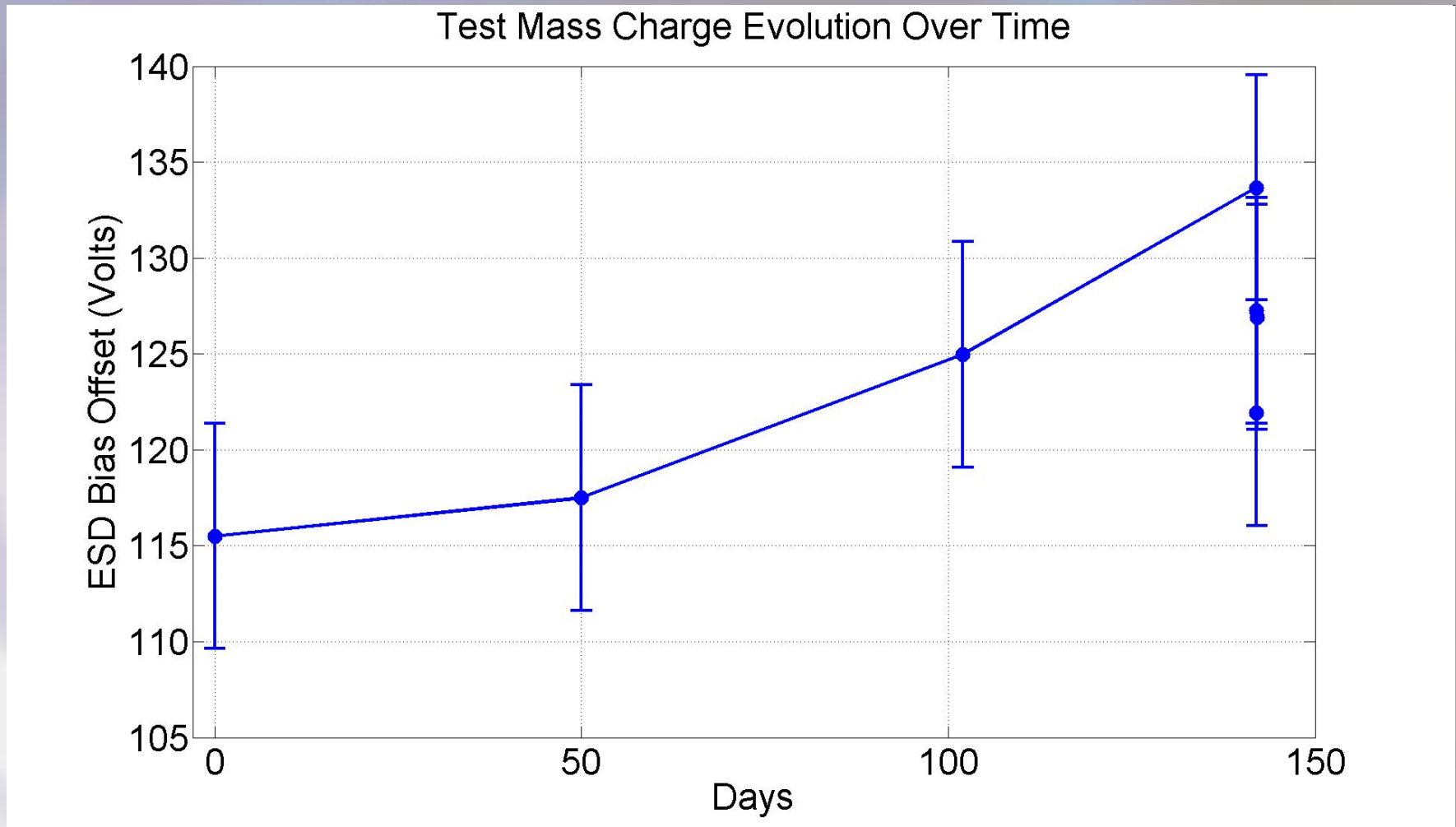


Venting



- Vent to atmosphere for a few days
- 9.8 V = -3 nC

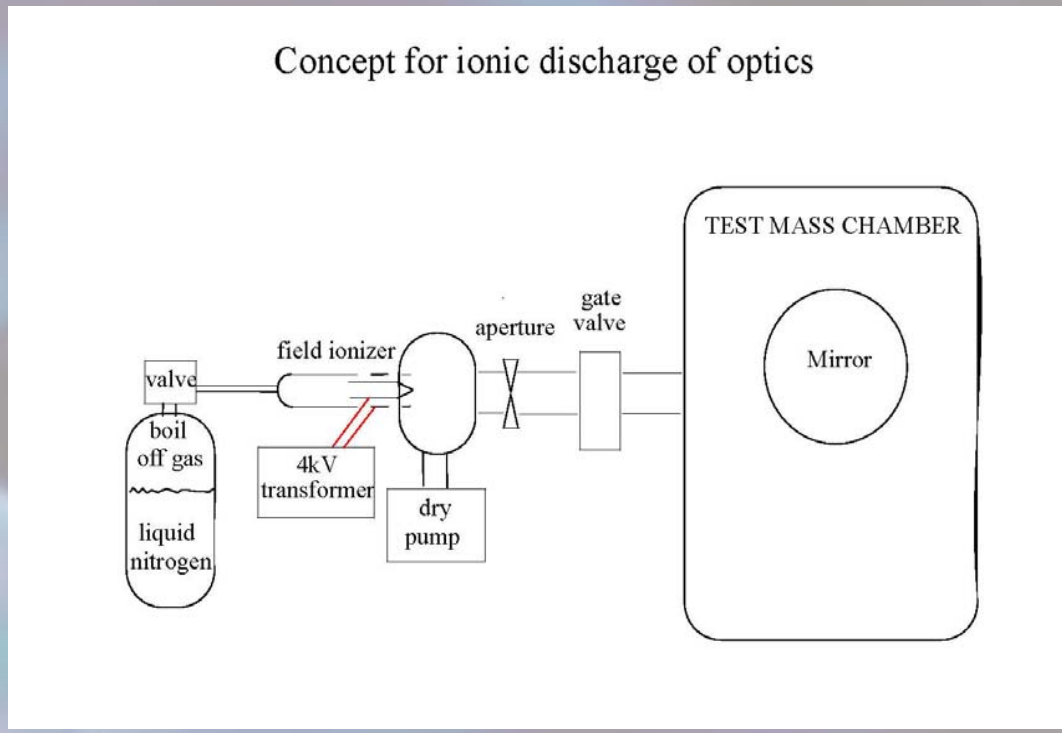
Charge over Time



- Single pumpdown

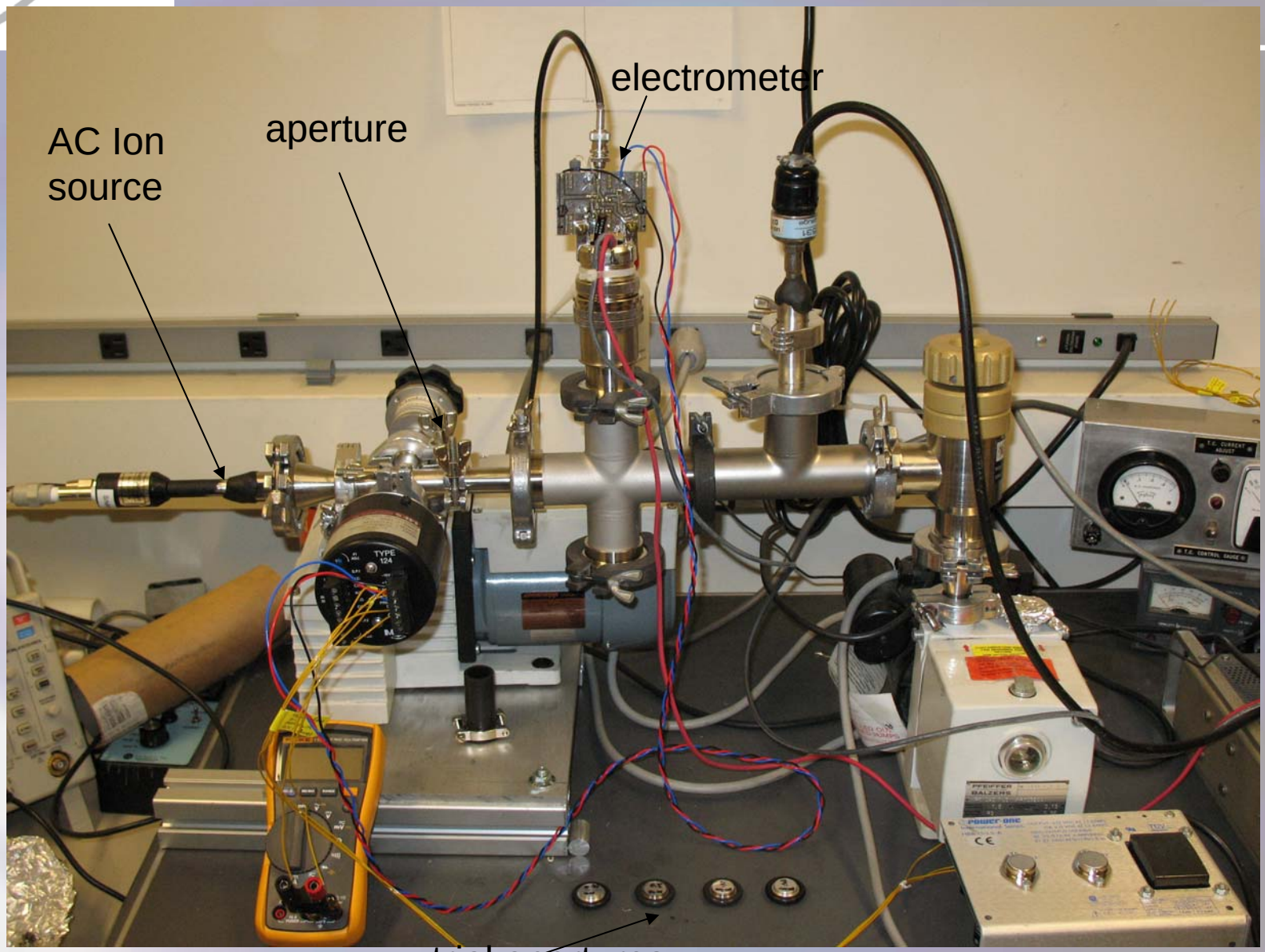
IONIC NEUTRALIZATION OF SURFACE CHARGE ON MIRRORS

- Technique
  - + and – nitrogen ions introduced from outside
  - Boil off from liquid nitrogen
  - Neutralization by thermal diffusion
- Advantages
  - Easy to do - all external
- Disadvantages
  - Requires stopping run ~ 1 day
  - Requires written procedure to avoid mistakes



Will try to test in LASTI May 2010

Test apparatus at MIT



Noise from Charge

Scenario	Charge Level	Markov Noise	Seismic Noise	Charge Noise/ aLIGO Noise
Point charge below stop	-9 nC	3×10^{-14} m/√Hz	1.5×10^{-13} m/√Hz	$1.3\ 10^{6}$
Uniform, high charge	-9 nC	2×10^{-20} m/√Hz	1×10^{-19} m/√Hz	1
Point charge, most likely level	-5 nC	9×10^{-15} m/√Hz	4×10^{-14} m/√Hz	400,000
Uniform, most likely	-5 nC	7×10^{-21} m/√Hz	3×10^{-20} m/√Hz	0.3
Point charge, low charge level	-0.2 nC	$1.5\ 10^{-17}$ m/√Hz	7×10^{-17} m/√Hz	600
Uniform, low charge	-0.2 nC	1×10^{-23} m/√Hz	5×10^{-23} m/√Hz	$5\ 10^{-4}$