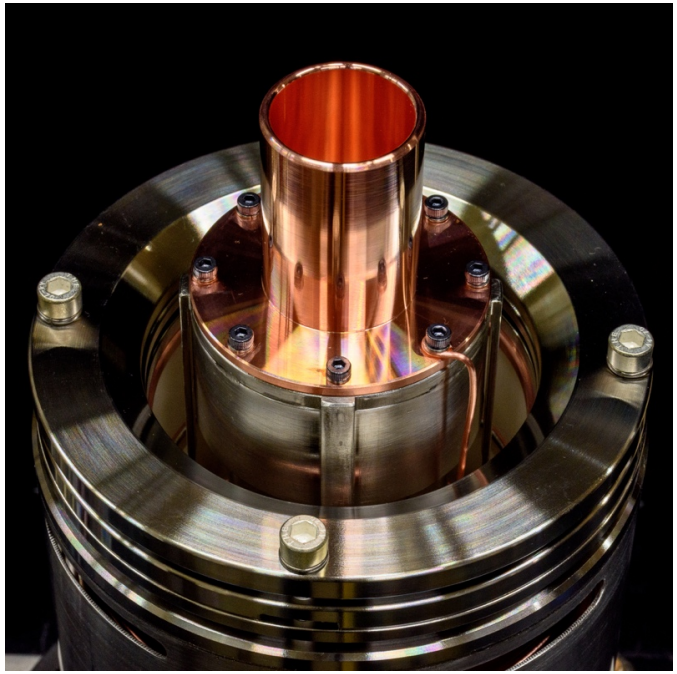
Characterization of the CERN scandate hollow electron gun (CHG-16-sc) at the Fermilab electron-lens test stand

Giulio Stancari
Fermilab



Materials for the HL-LHC Collaboration Meeting of October 2018

Contributors

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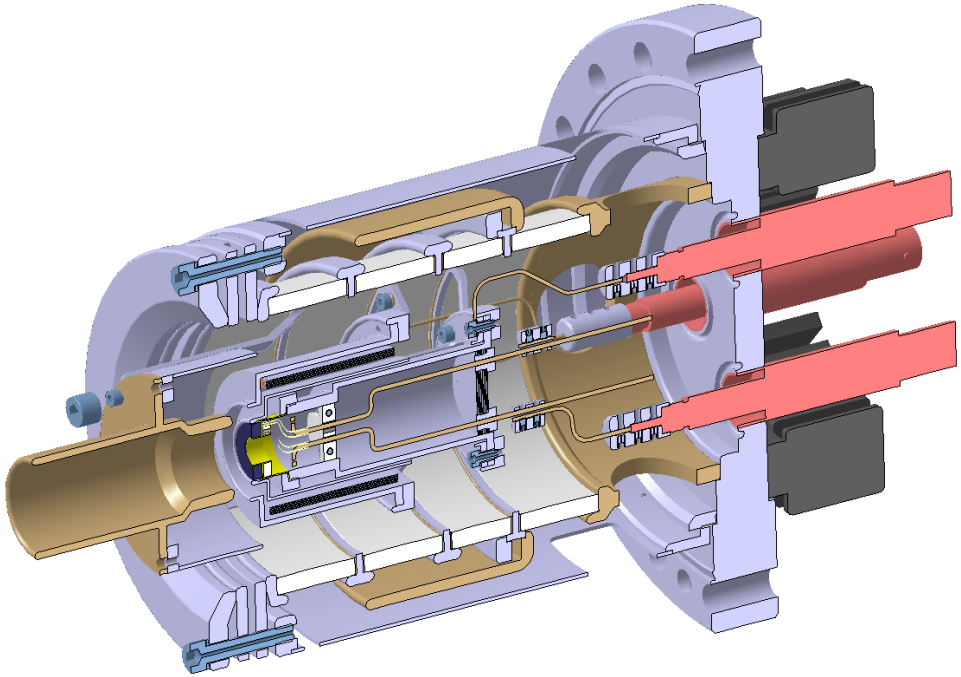
Motivation

For HL-LHC hollow electron lenses, test scandate cathodes from Beijing Vacuum Electronics Research Institute (BVERI):

- higher current densities; uniformity? lifetime?
- smaller dimensions to match proton beam sizes
- scaled electrode dimensions to match perveance of CHG1 e-gun



Timeline

2018.04.26 Parts assembled at CERN

2018.05.15 Parts arrived at Fermilab

2018.06.05 Installation of 16-mm cathode on CHG1b e-gun body at Fermilab

2018.06.06 - 2018.07.20 First heating and conditioning of cathode; diagnosis of vacuum issues

2018.07.09 Start of Fermilab complex summer shutdown: no cooling water in e-lens test stand solenoids and collector

2018.07.22 First measurements of yield vs. voltage and temperature (solenoids off)

2018.08.28 - 2018.09.02 Re-heating and conditioning

2018.09.02 Re-measured yield vs. voltage and temperature (solenoids off)

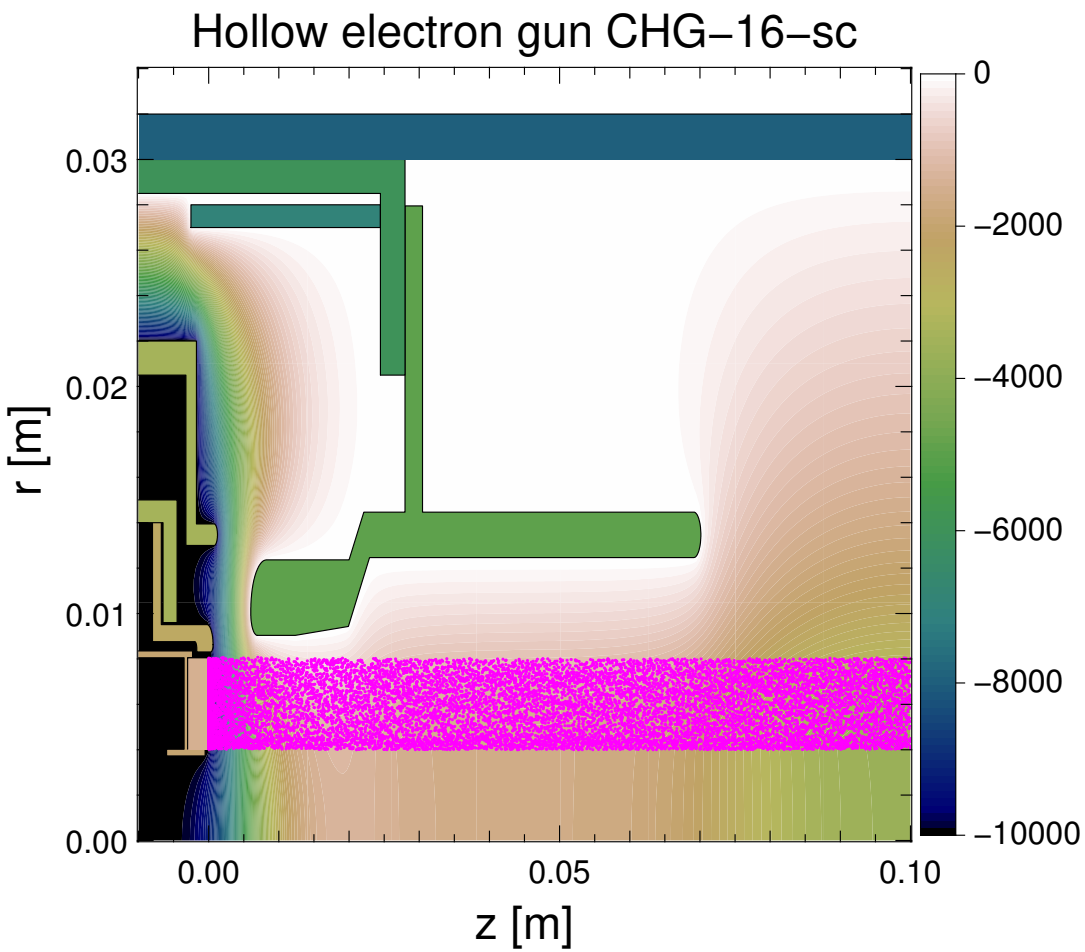
2018.09.21 End of Fermilab complex summer shutdown

2018.10.01-04 Re-heating for yield measurements with solenoids on

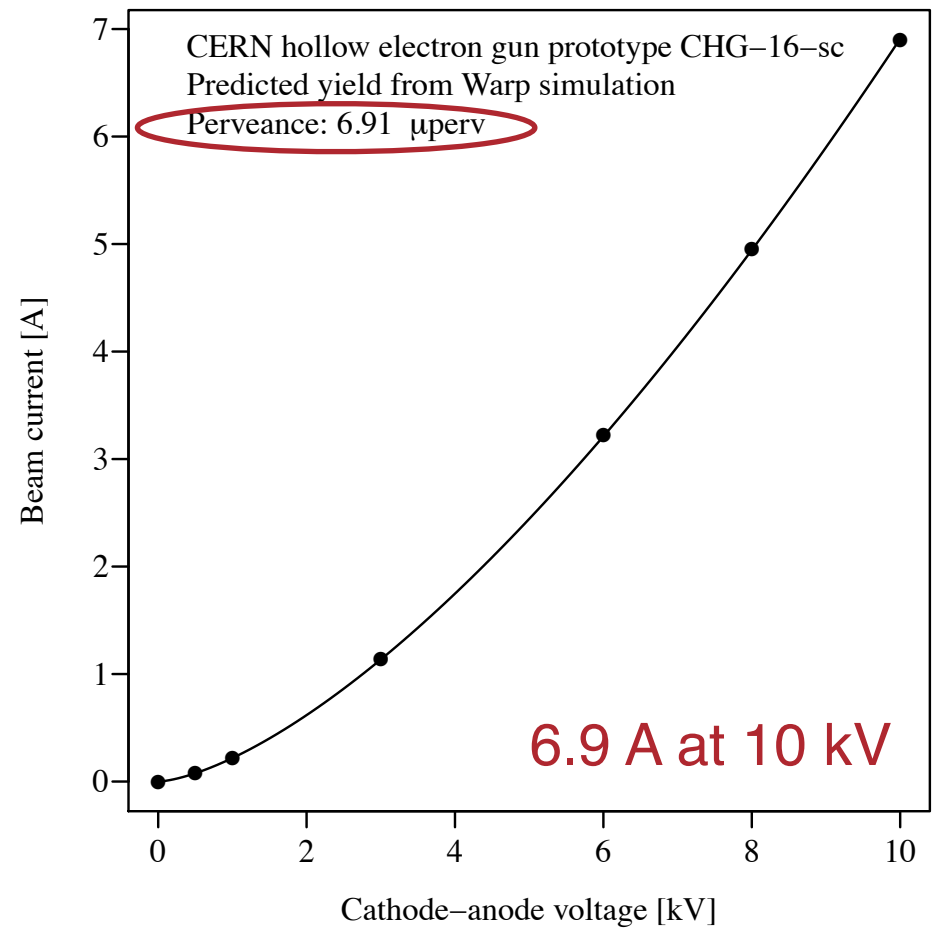
Simulations of expected yield and profile

Warp particle-in-cell code

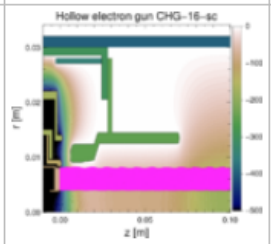
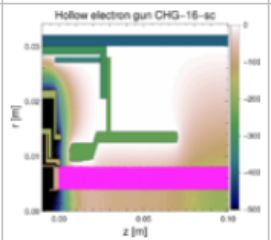
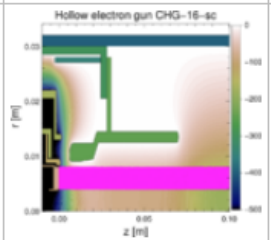
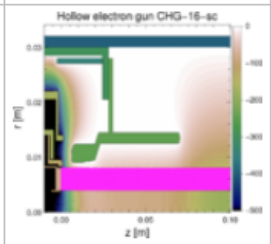
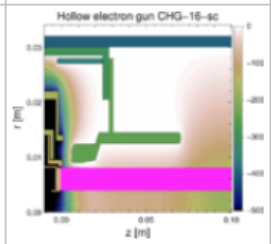
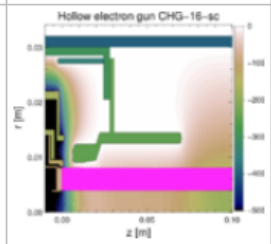
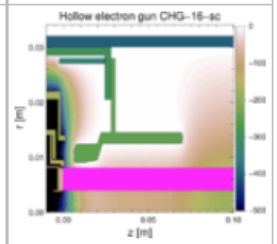
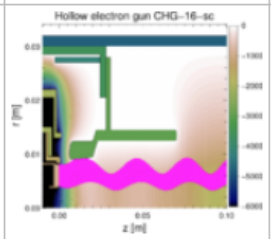
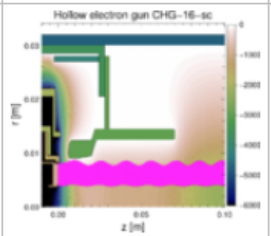
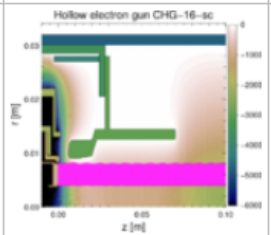
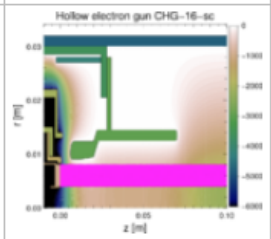
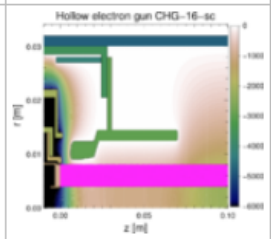
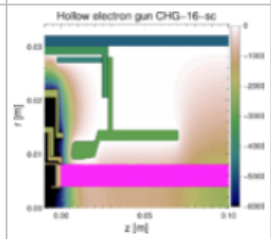
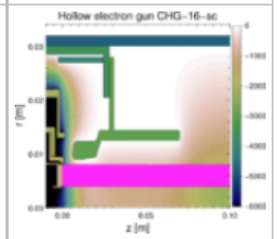
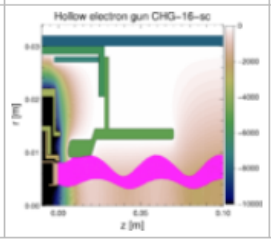
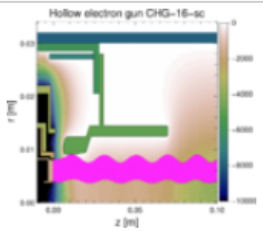
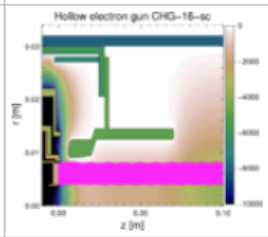
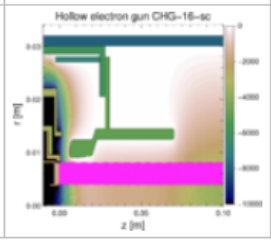
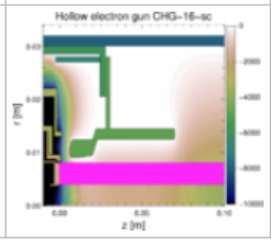
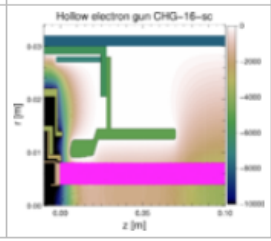
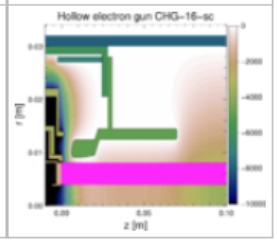
Example of emission at 10 kV, 0.4 T



Expected yield vs. voltage



Simulated emission vs. voltage and magnetic field

	0.05 T	0.1 T	0.2 T	0.3 T	0.4 T	0.5 T	1.0 T
0.5 kV, 78 mA							
6 kV, 3.22 A							
10 kV, 6.91 A							

Installation

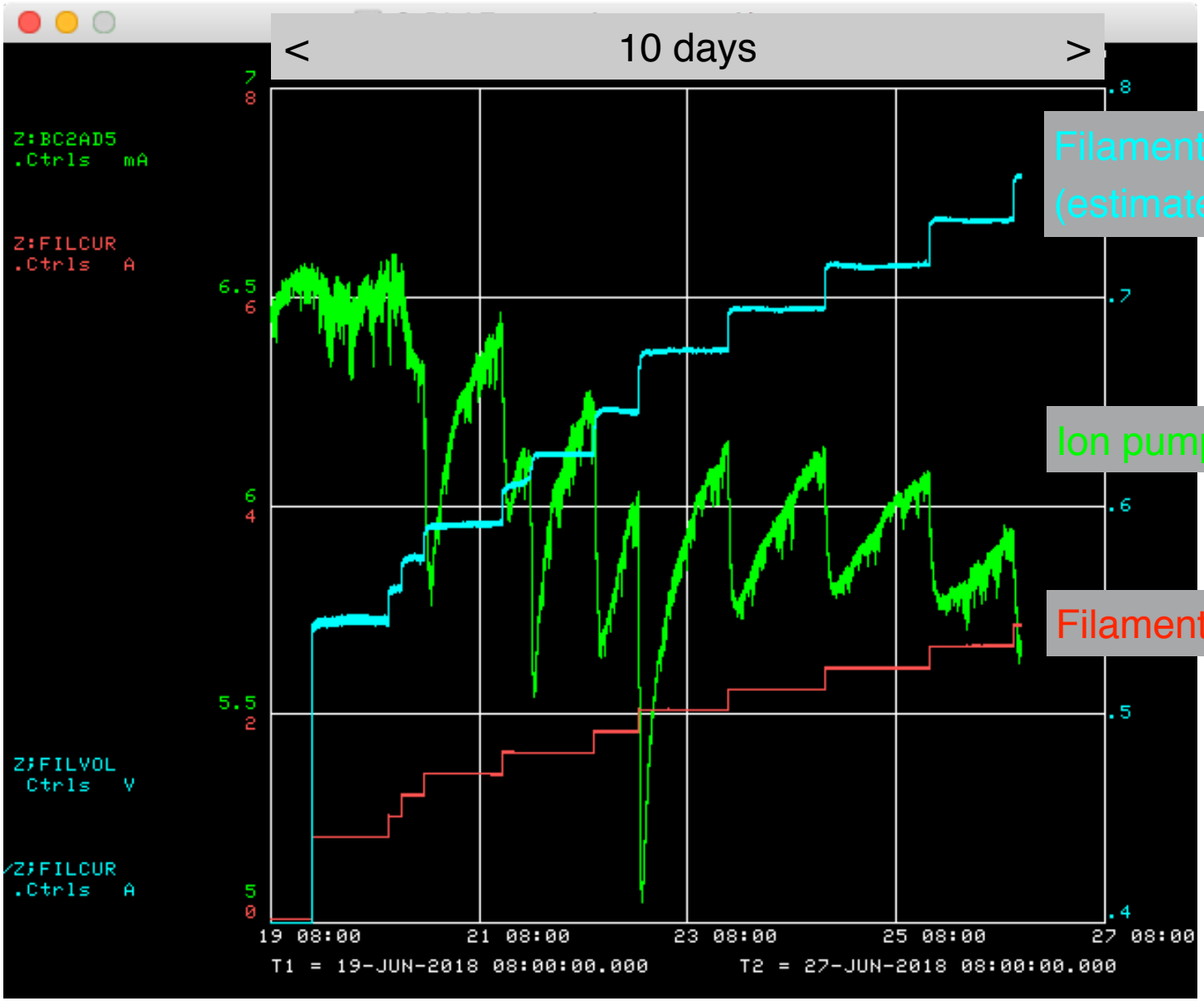
16-mm scandate cathode installed in CHG1b electron gun body at Fermilab electron-lens test stand on June 5, 2018 by Coiffet, Gobbi, Stancari and Crawford

The new e-gun assembly is named CHG-16-sc (CERN hollow gun, 16 mm diameter, scandate cathode)

See installation pictures at

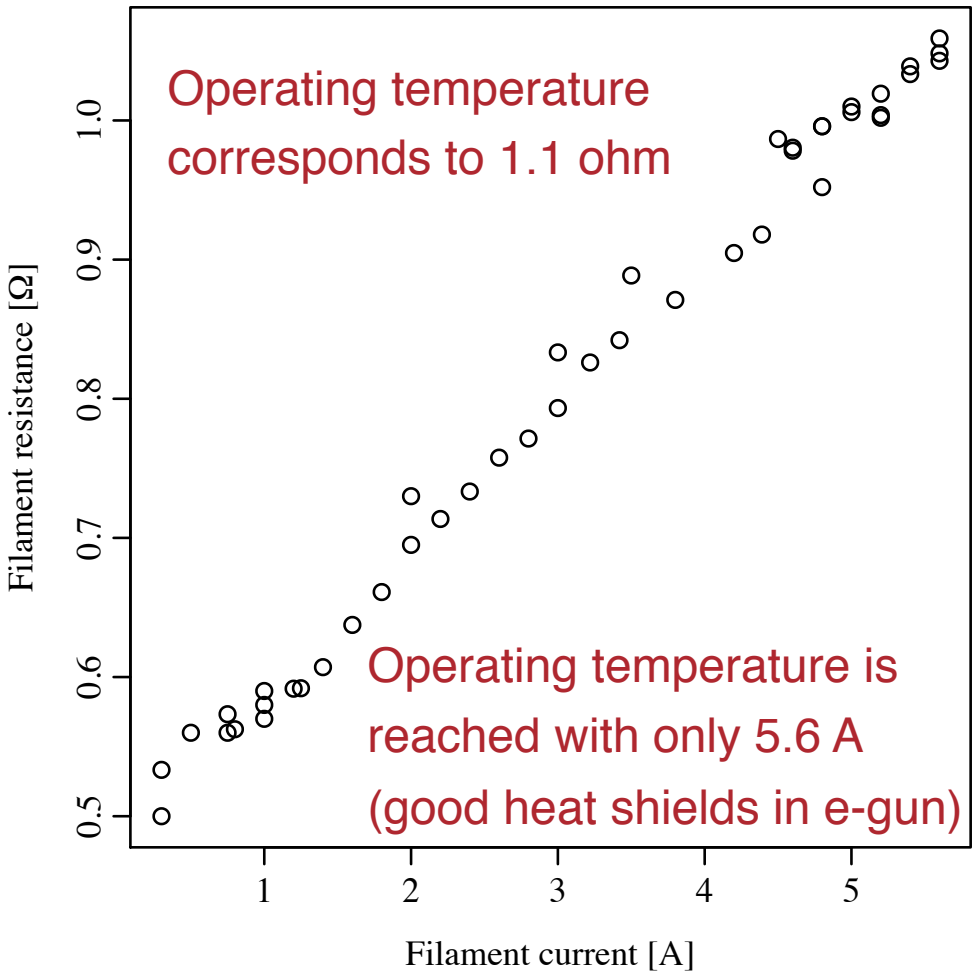
`http://home.fnal.gov/~stancari/pics/2018-06-05_CHG-16-sc_egun_installation/index.html`

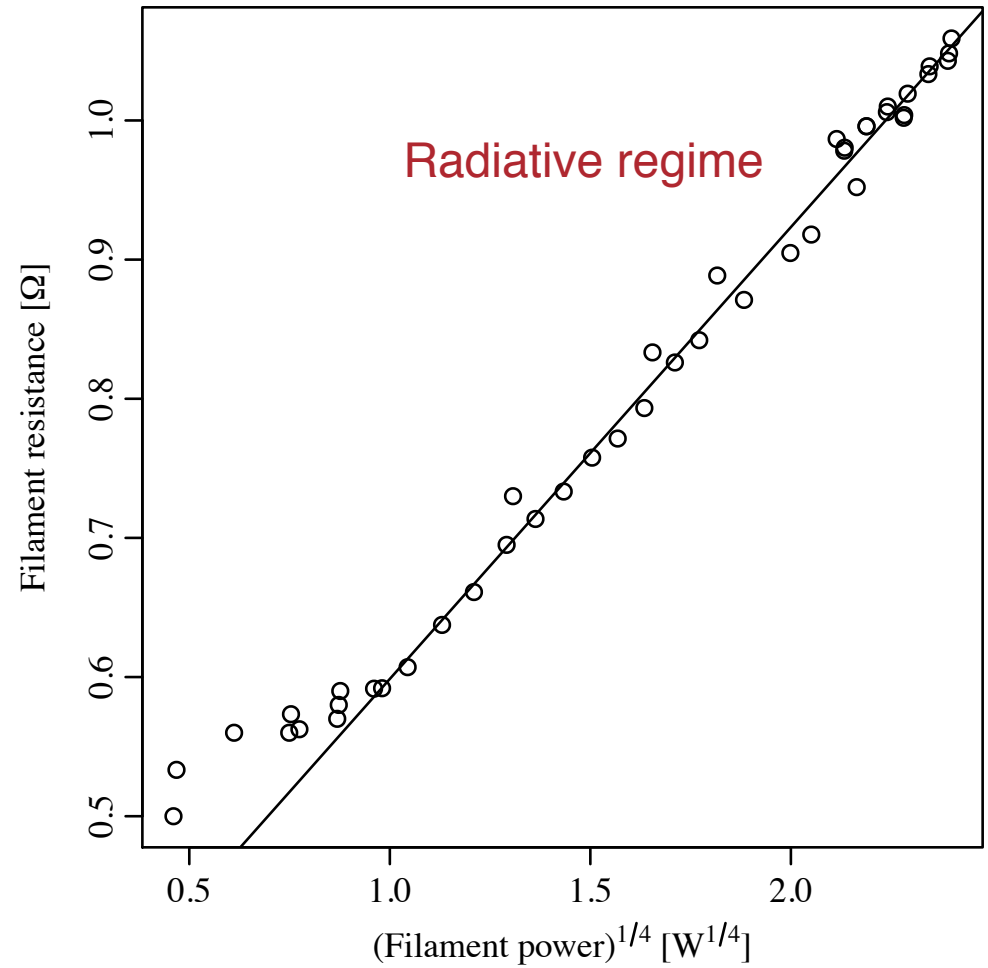
Cathode filament heating



Example of first heating procedure

Cathode filament heating





Reference heater data
(in metal chamber)
from manufacturer

Operating temperature >>

Voltage of Heater（V）	Current of Heater（A）	Temperature（℃$_B$）	Knee Point of I-V Curve J_{kp}(A/cm^2)	Knee Point of I-V Curve I_{kp}(mA)
5.67	5.55	800	0.44	664
6.39	6.09	850	2.2	3318.
6.87	6.38	900	4.1	6236
7.84	7.03	950	>5.6	>8400

Observations during heating

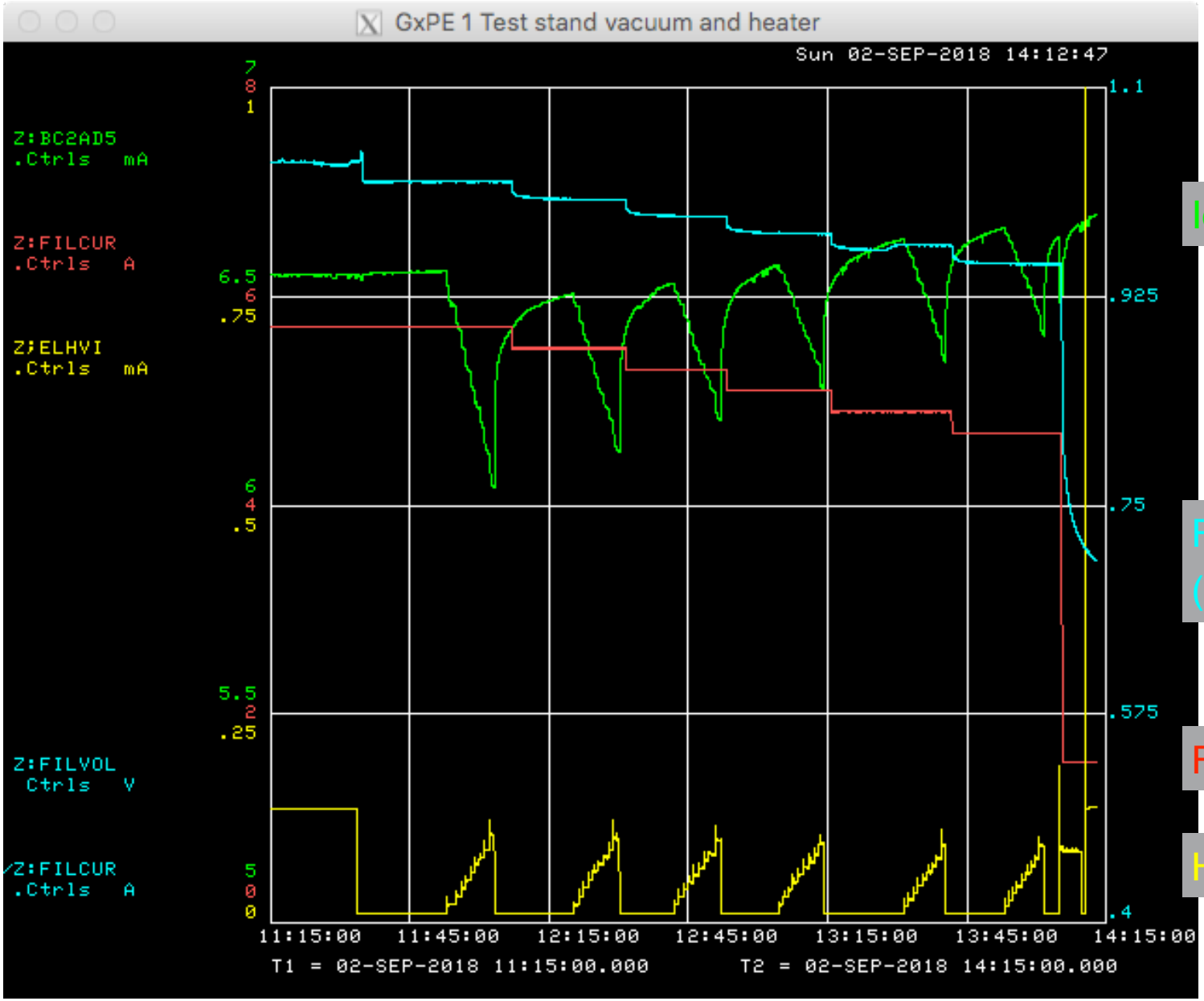
Unusual fluctuations of residual gas pressure during first heating. Tests pointed to three main factors:

- outgassing of e-gun (air pockets in new design?)
- aging of one ion-getter pump; improved after high-voltage conditioning
- one faulty HV ion-pump controller; replaced

Some glitches and fluctuations in filament resistance. No major consequences, but they may be an indication of fragile internal connections.

Second and third heating ramps were faster and smoother.

Measurement of yield vs. temperature and voltage



Ion pump vacuum monitor

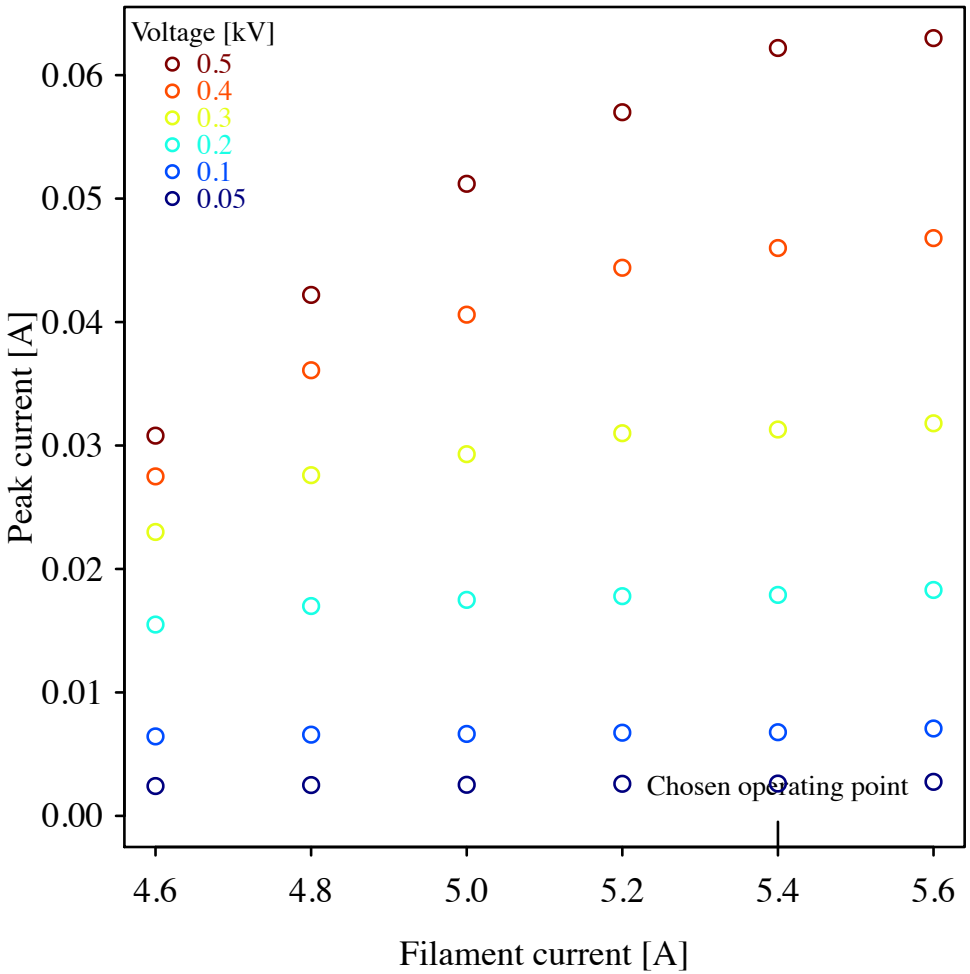
Filament resistance (estimate of temperature)

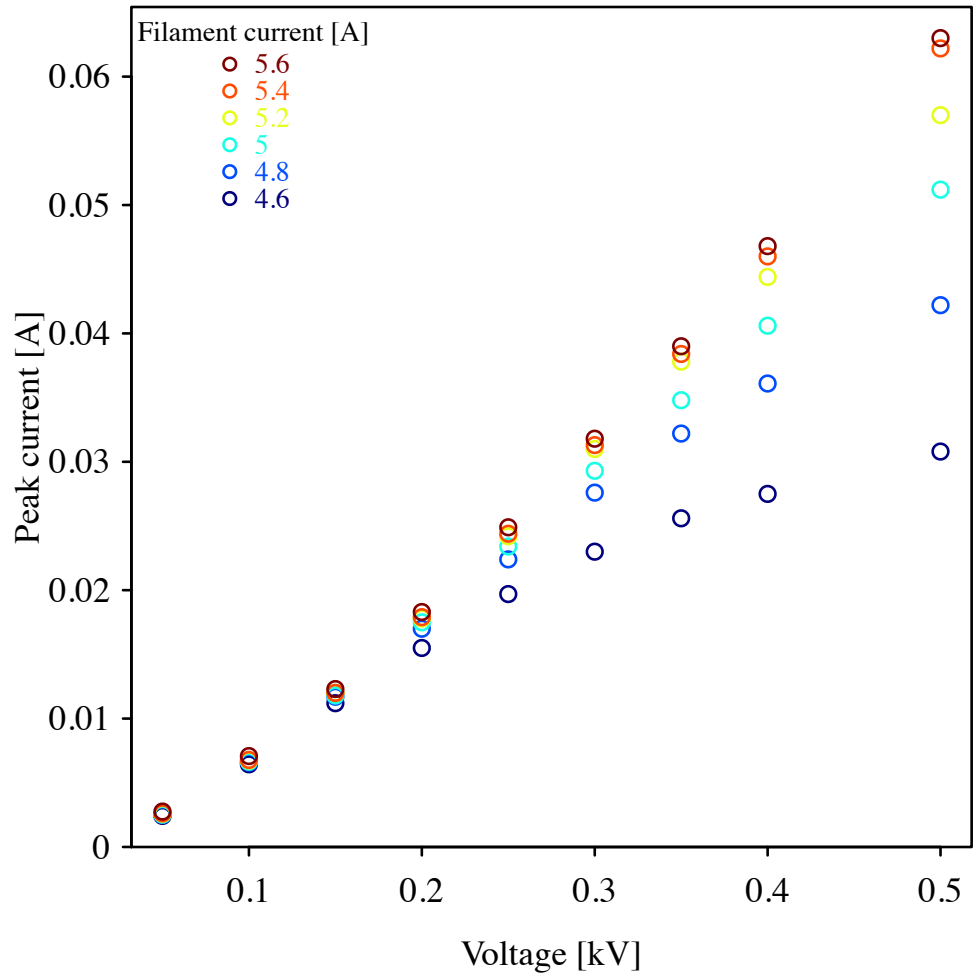
Filament current

HV PS current

Yield vs. temperature and voltage (solenoids off)

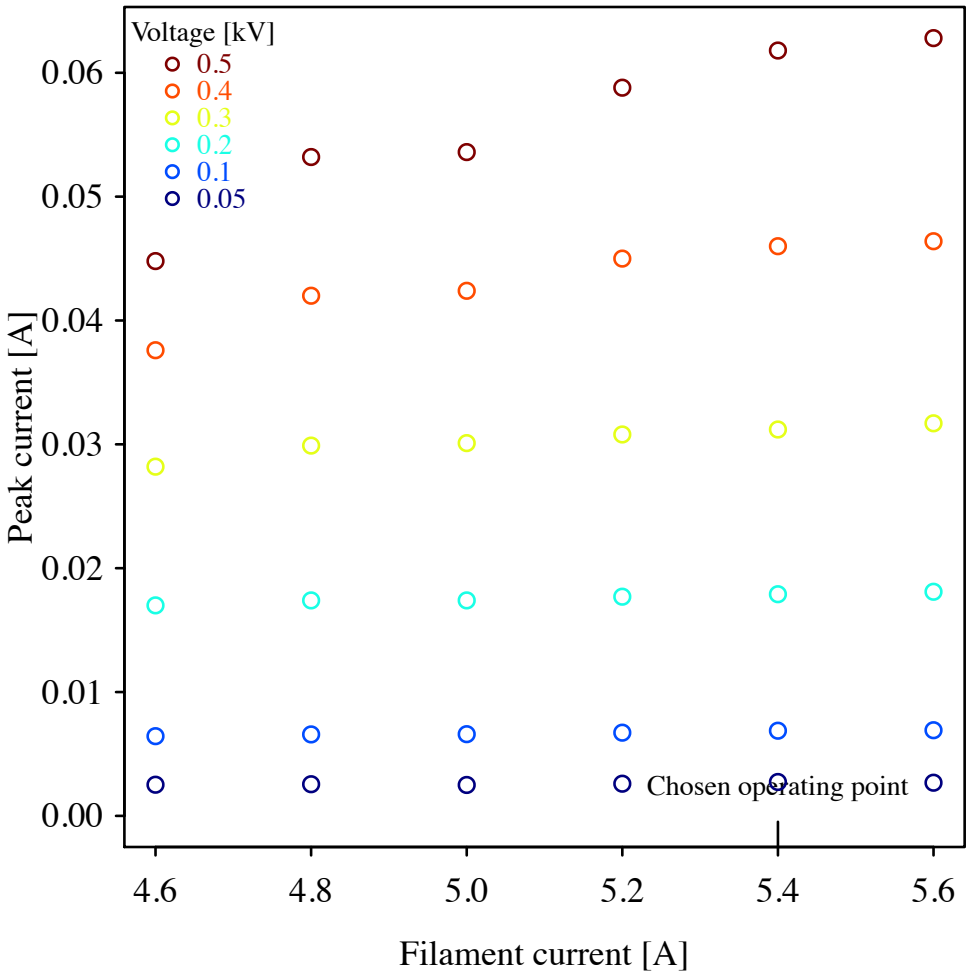
July 22

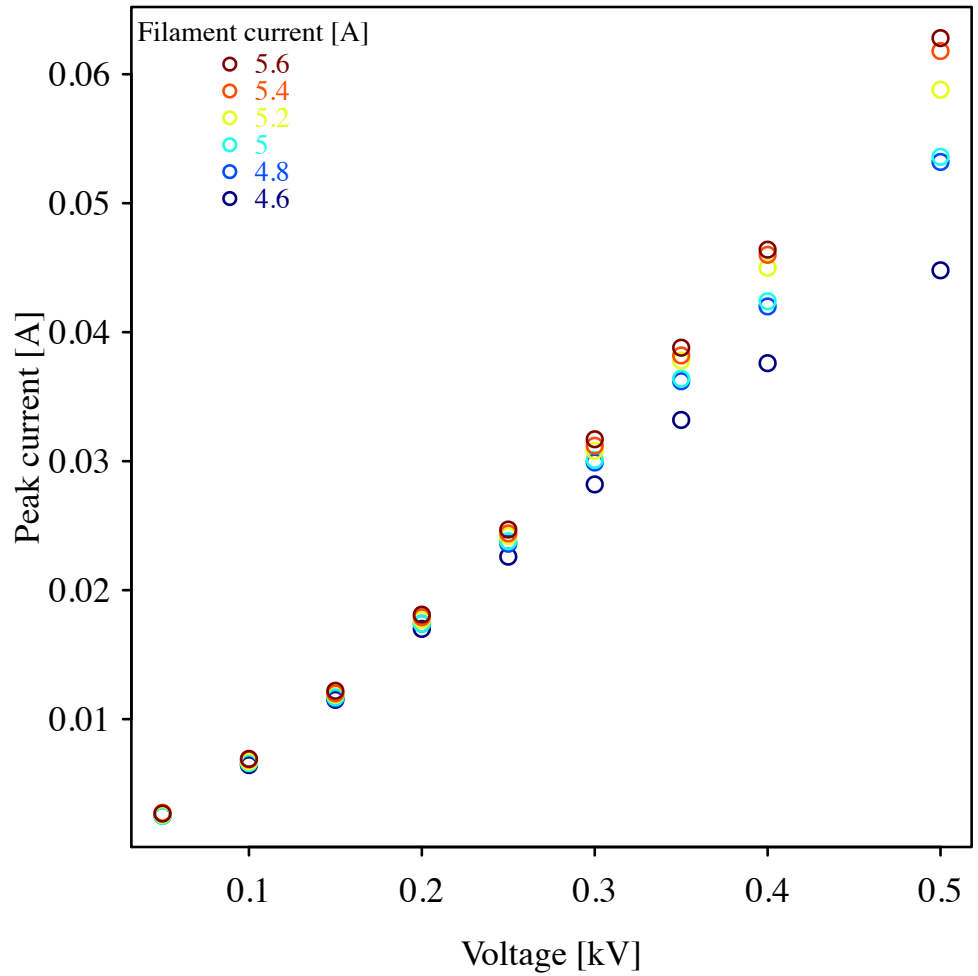




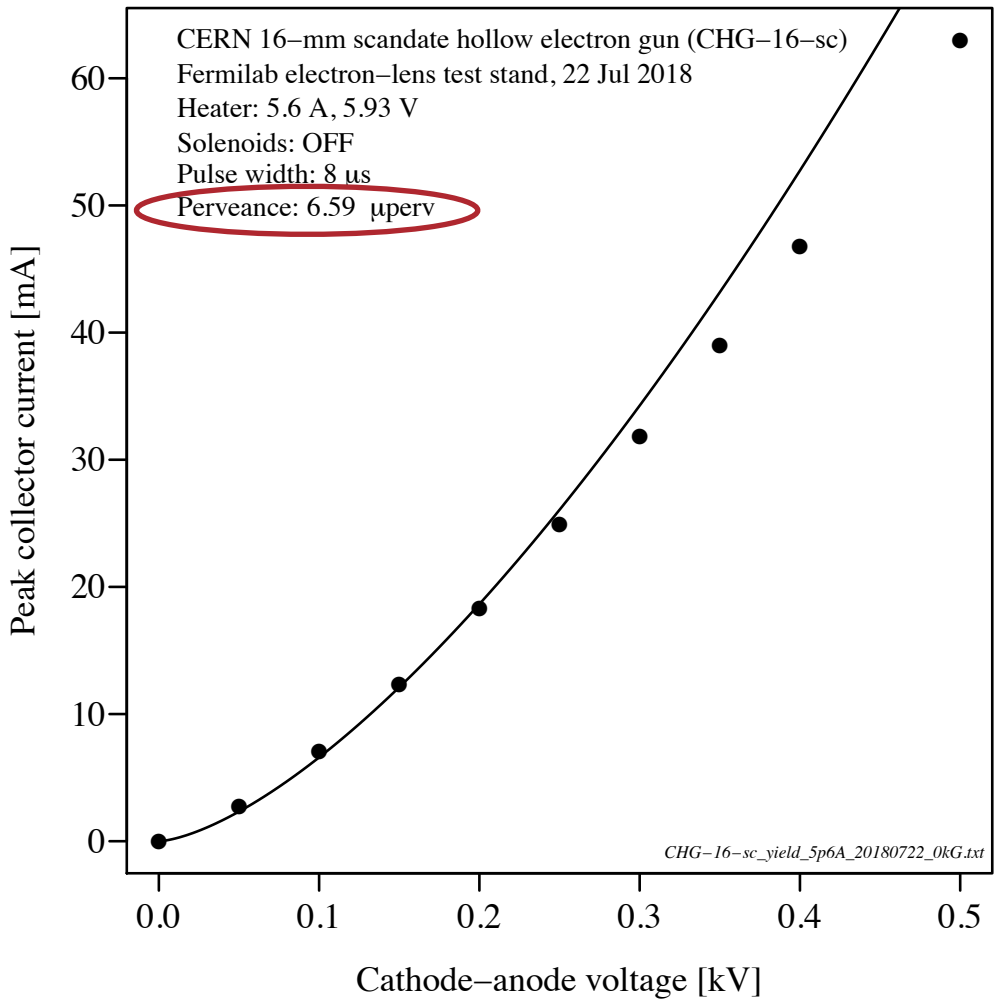
Yield vs. temperature and voltage (solenoids off)

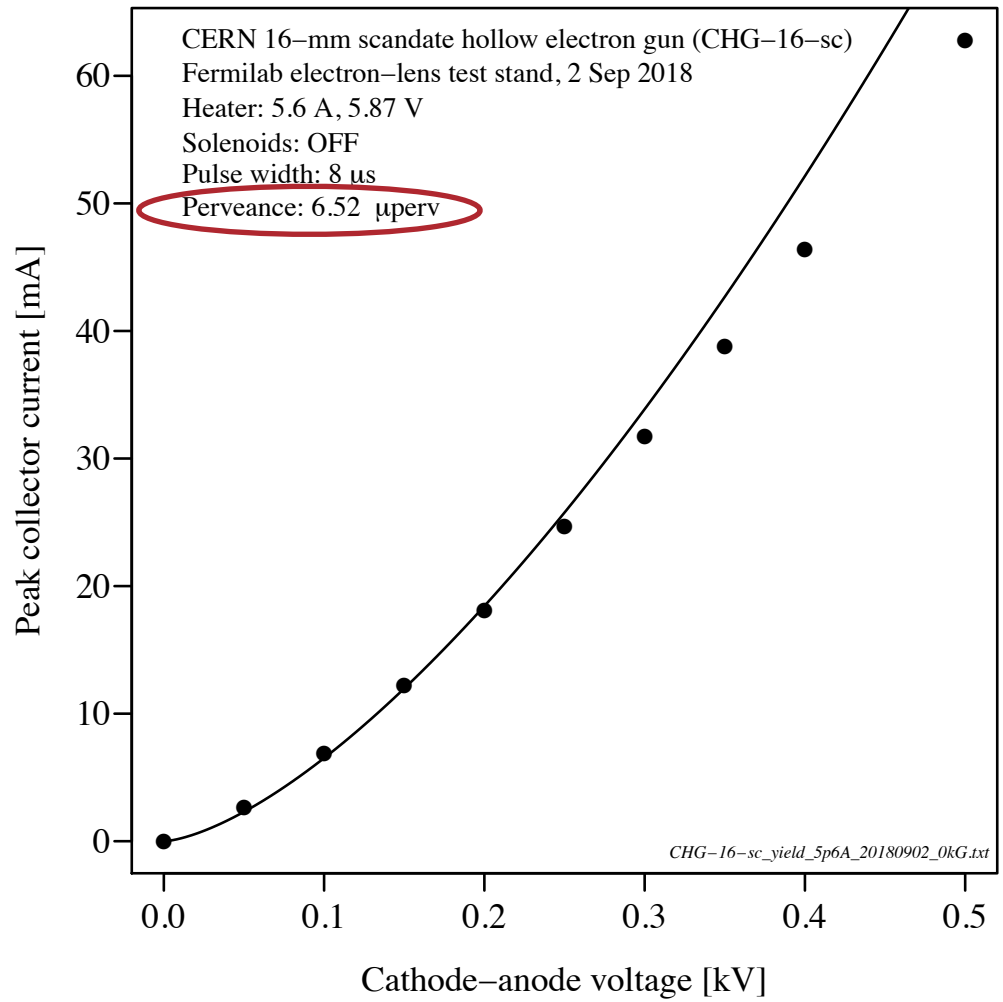
Sep 2





Yield vs. voltage (solenoids off)





Measured only up to 0.5 kV to contain losses and vacuum degradation

Perveance is good and within 5% of calculated value