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Title: Beam Development_V6MP

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Intended for: Send to Mike Plum of SNS.

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Conditions....

- **In CCR,**
 - Loss Measurements, 03AP – McCrady
 - FTP files to Flash Drives via Laptop, took notes - Sedillo
 - Running WSNAD and expert screens - Gilpatrick
- **Gates: LBEG, MPEG, and H+IP**
- **Beam conditions: 4 Hz, 0.15 ms; 7.5- to 12.75-mA_{pk}**
- **Wire Biased at -12 Volts**
- **Tungsten (W) sense wire; 0.1 mm**
 - Density = 19.3 g/cm³
 - Assumed square wire cross-section for simplicity
- **“New” wire scanners in locations 03WS001, 04WS001, 10WS001, 11WS001, 14WS001, 15WS001, 16WS001, 17WS001, LXWS005.**
 - Took data at 03WS001, 04WS001, 10WS001, 11WS001

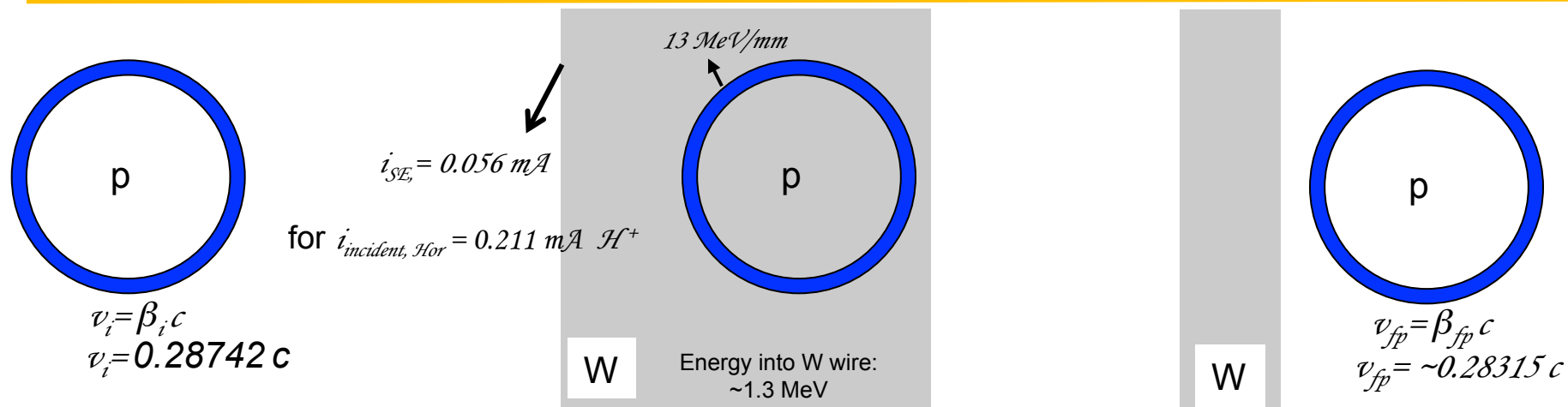
Sternglass states.....

$$\Upsilon = \frac{Pd}{\varepsilon} \frac{dE}{dx} = \left(0.002 \text{ cm/MeV} \right) \frac{dE}{dx}$$

- Υ is the SE yield from a proton beam current impinging on the W wire
 - P is the probability that an electron will escape from the W wire material (typically, ~ 0.5)
 - d is the average depth from which electron escape from the W wire material (typically, $\sim 1 \text{ nm}$)
 - ε is the average amount of kinetic energy lost by an ion per ionization in material (typically, $\sim 25 \text{ eV}$)
 - $\frac{dE}{dx}$ is the stopping power of the H^+ or H^- beam with the material density taken into account.
- The secondary electron emission current, i_{SE} , from a beam impinging on a sense wire, i_{Beam} , is

$$i_{SE} = \Upsilon i_{Incident}$$

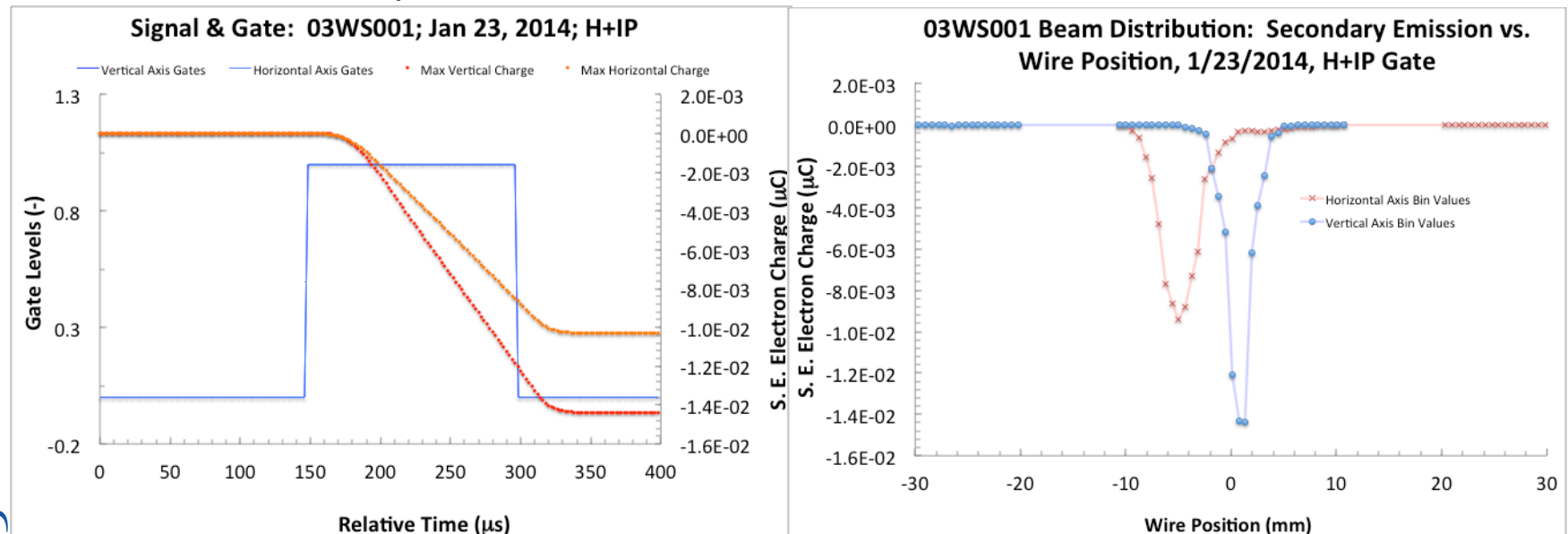
H⁺ beam interacts with a W sense wire – Sternglass theory for SE current.



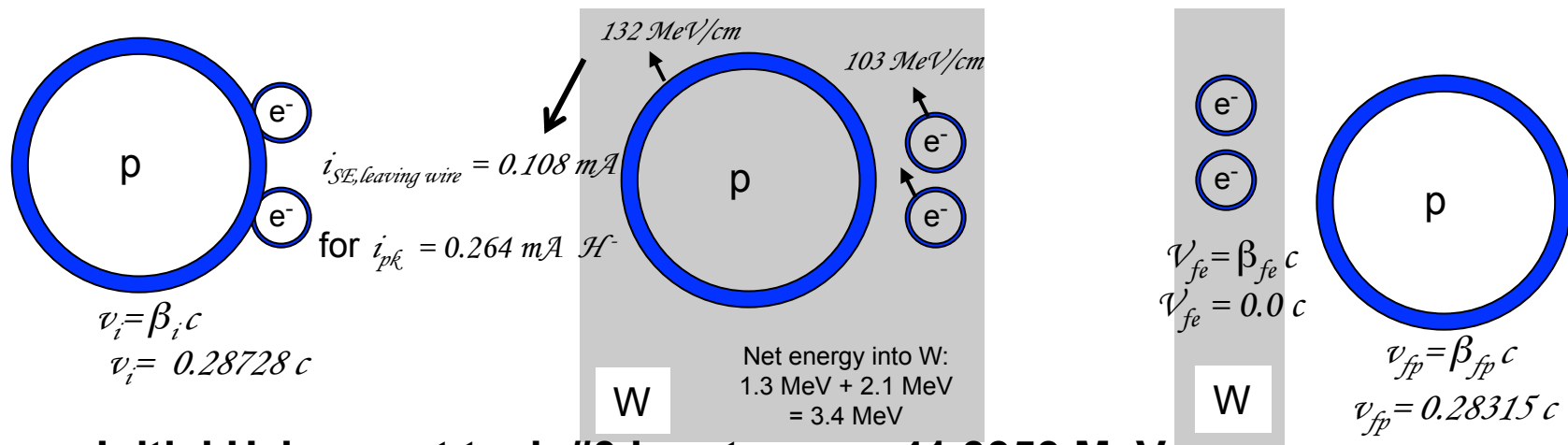
- **Initial H⁺ beam at tank #3 input: nom. 41.3353 MeV**
 - ~1 secondary electron for every 3.8 incident protons impinging on wire material
 - Stopping Power = ~132 MeV/cm in W; Range (CSDA) = ~0.19 mm in W
- **H⁺ beam at spatial peak, 0.211 mA incident current, normalized to 10 mA**
 - 2.47- X 1.31-mm (1.89 mm - round beam), 12.75-mA (TDCM001), 4-Hz X 0.15-ms, H +IP gated beam

Observed H⁺ beam at 03WS001 location; Jan 23 data

- Beam dq and dt : 14.4- or 10.3-nC in 140 μ s or 0.087 mA incident beam for a total of 12.75 mA_{pk} (TDCM001), normalized to 10 mA.
 - Rms width: 2.47 mm (Hor) X 1.31 mm (Ver)
- Secondary emission current: -0.069 mA at spatial peak
 - Comparison: ~-124%, current of Sternglass theory (compared to 0.056 mA)
 - Should be a “positive” distribution; electron flow vs. “conventional” flow



H⁻ beam at 03WS001 location, Jan 23 data, Sternglass theory for SE current

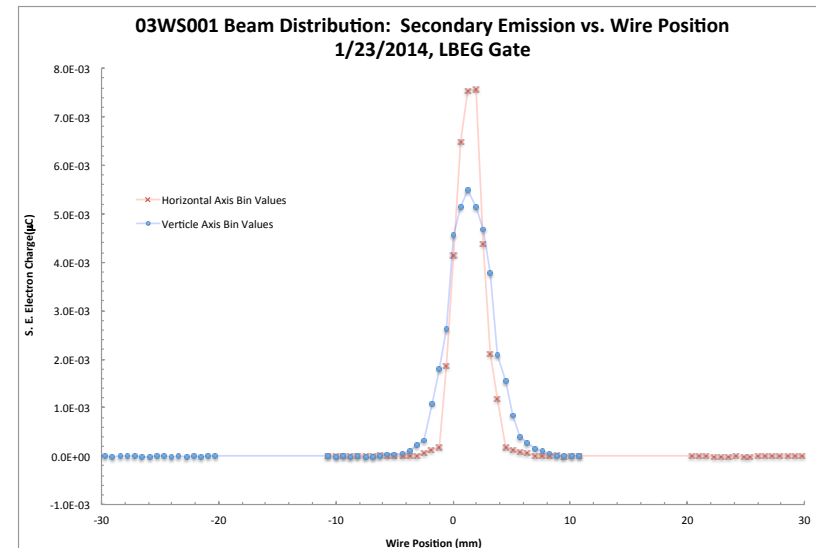
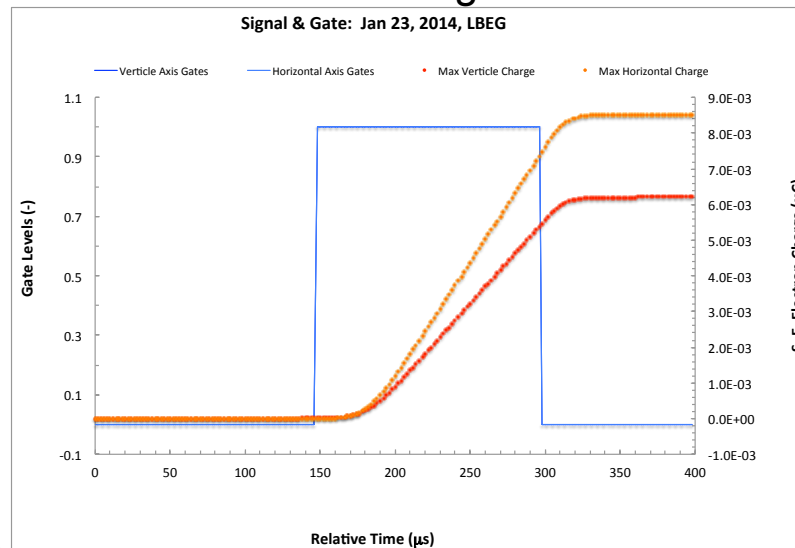


■ Initial H⁻ beam at tank #3 input: nom. 41.3353 MeV

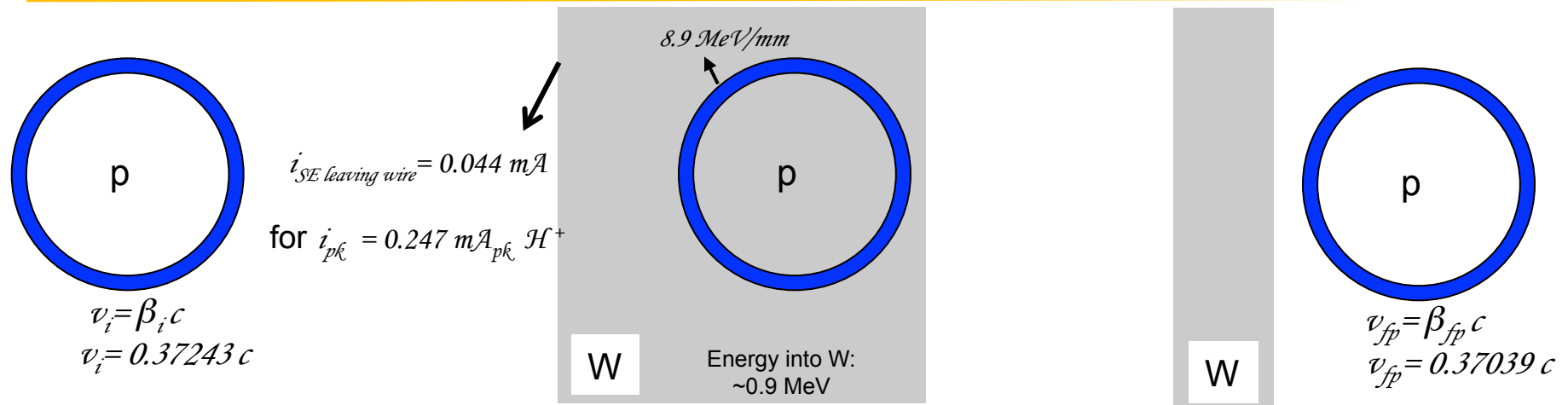
- Total: ~1 secondary electron for every 2.44 incident H⁻ particles into W wire
 - ~1 secondary electron for every 3.79 incident H⁻ particles into wire
 - Stopping Power = 132 MeV/cm in W; Range (CSDA) = ~0.19 mm in W
 - ~1 secondary electron for every 4.85 incident H⁻ particles into wire; however, 2 electrons per incident H⁻ particle are stripped and stopped in wire.
 - Stopping Power = 103 MeV/cm in W; Range (CSDA) = 0.00014 cm in W
 - Right after stripping, electrons energy: 22.48 keV
- H⁻ Impingement at spatial peak, 0.264 mA incident current, normalized to 10 mA

H⁻ beam at 03WS001 location; Jan 23 data

- Observed peak dq and dt ; average of 8.5- or 6.2-nC in 140 μ s, $N_{\text{avg}} = 1$, 4-Hz X 0.15-ms beam or 0.053 mA
 - Observed 10.5 mA_{pk} at TDCM001, normalized to 10 mA
 - Rms width: 1.18 mm (Hor) X 1.85 mm (Ver)
 - Observed current: 0.050 mA at spatial peak
 - Observation, ~46% current of Sternglass theory (compared to 0.108 mA)
 - Should be a “negative” distribution; electron flow vs. “conventional” flow



H⁺ beam at 04WS001 location, Jan 23 data, Sternglass theory for SE current



■ Initial H⁺ beam at tank #4 input: nom. 72.7322 MeV

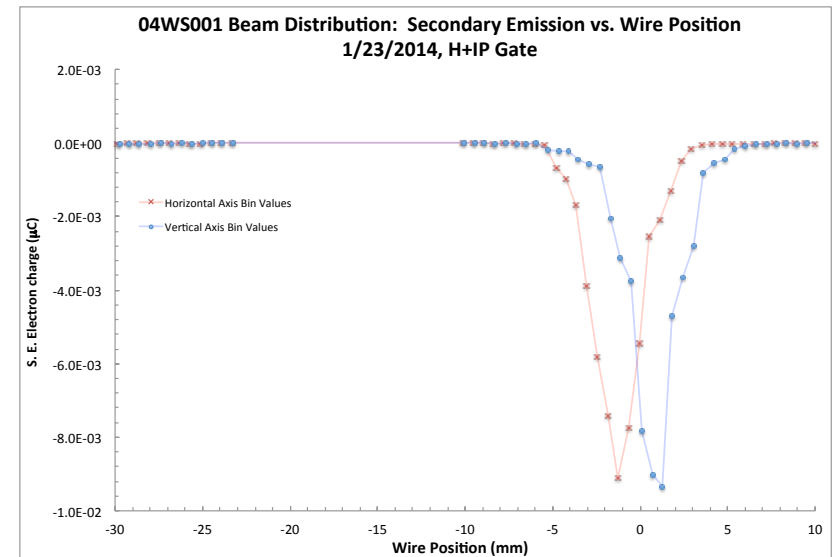
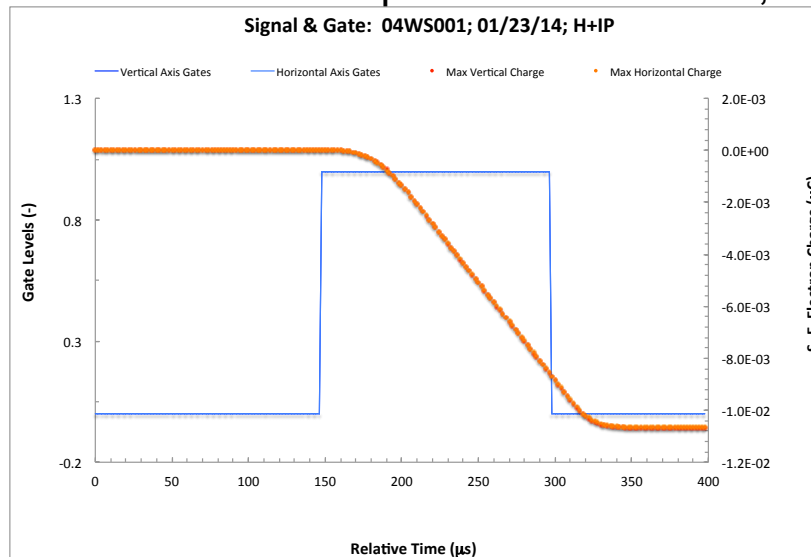
- About 1 secondary electron (SE) for every 5.6 incident protons into wire material
 - Stopping Power = $\sim 88.8 \text{ MeV/cm}$ in W; Range (CSDA) = $\sim 0.48 \text{ mm}$ in W

■ H⁺ beam at spatial peak, 0.247 mA incident current, normalized to 10 mA

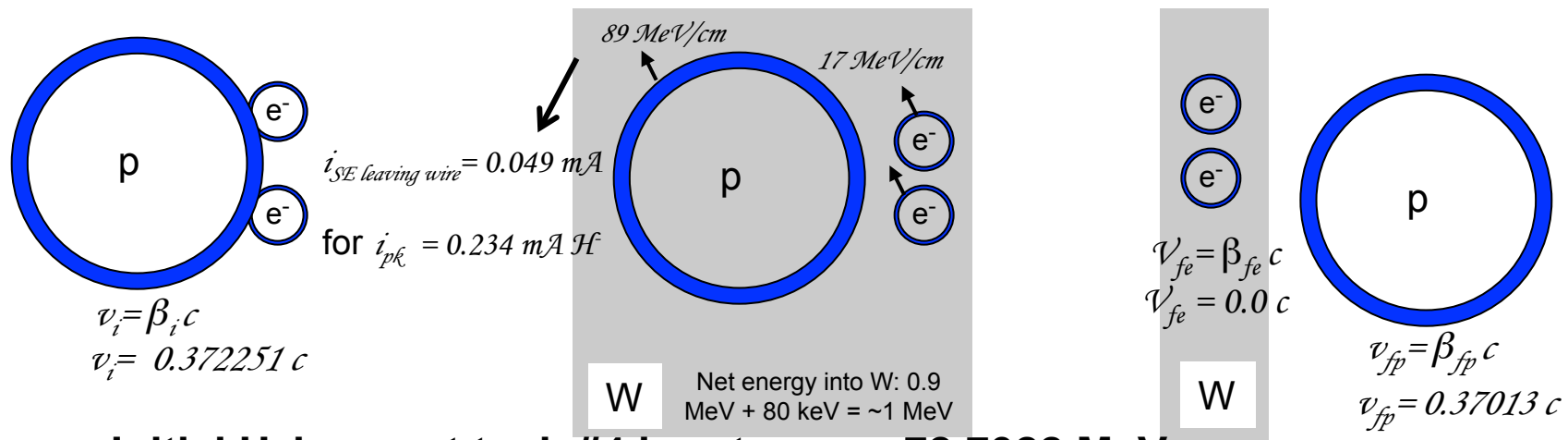
- 1.53- X 1.65-mm (1.61 mm – projected round beam), 12.75-mA (TDCM001), 4-Hz X 0.15-ms beam, H+IP gated beam

H⁺ beam at 04WS001 location; Jan 23 data

- Observed peak dq and dt : 10.7 nC in 140 μ s, $N_{\text{avg}} = 1$, 4-Hz X 0.15-ms beam or 0.076 mA
 - Observed 12.75 mA_{pk} at TDCM001, normalized to 10 mA.
 - Rms width: 1.53 mm (Hor) X 1.65 mm (Ver)
 - Observed peak current: ~ -0.060 mA at spatial peak
 - Observation, $\sim -136\%$ current of Sternglass theory (compared to 0.044 mA)
 - Should be a “positive” distribution; electron flow vs. “conventional” flow



H⁻ beam at 04WS001 location, Jan 23 data, Sternglass theory for SE current

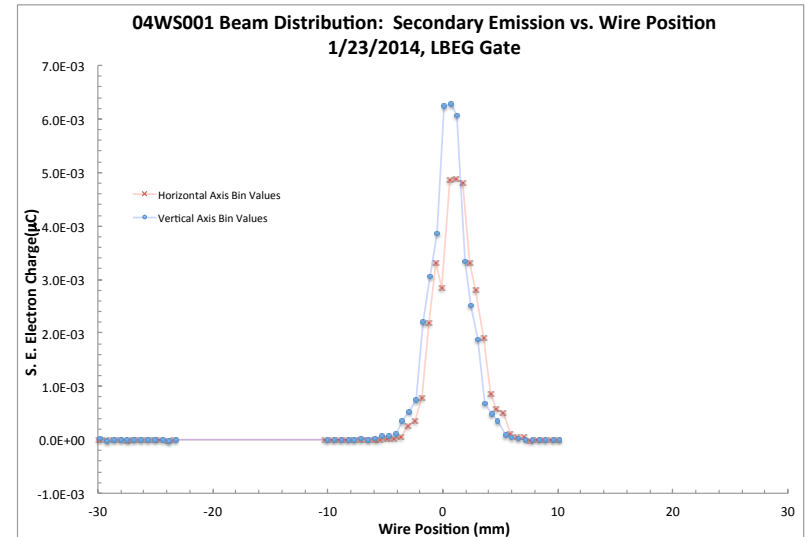
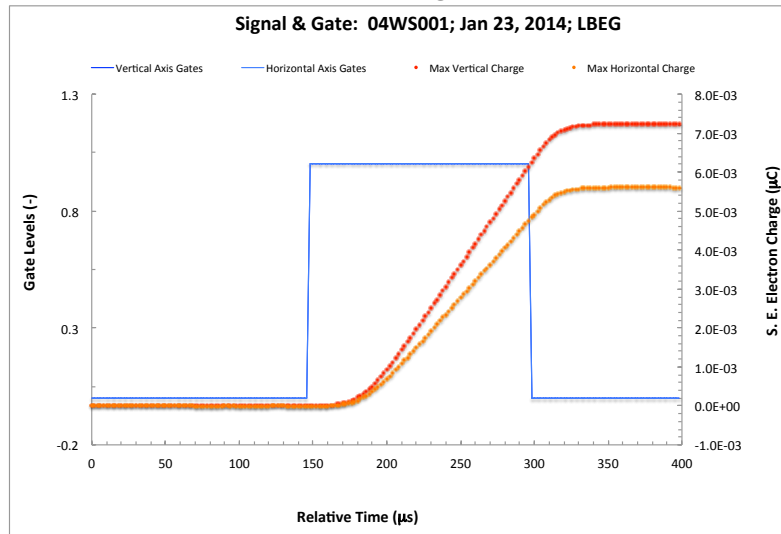


■ Initial H⁻ beam at tank #4 input: nom. 72.7322 MeV

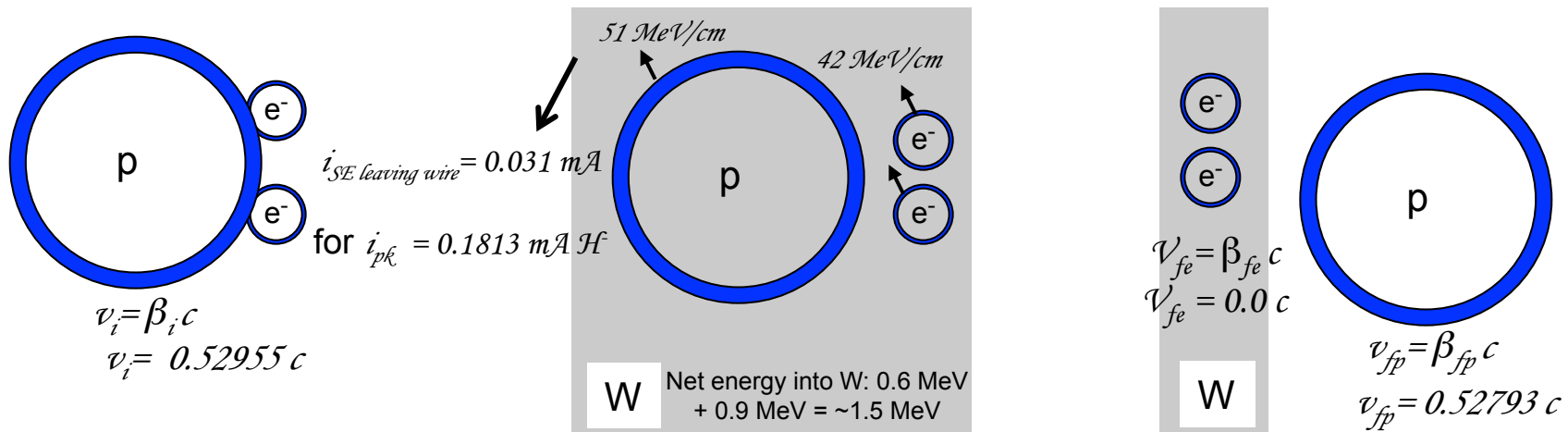
- Total: ~1 secondary electron for every 4.767 incident H⁻ particles into W wire
- ~1 secondary electron for every 5.63 incident protons (in H⁻ particles into wire)
 - Stopping Power = 88.8 MeV/cm in W; Range (CSDA) = ~0.48 cm in W
- ~1 secondary electron for every 29.1 incident electron (in H⁻ particles into wire), however, 2 electrons per incident H⁻ particle are stripped and stopped in wire.
 - Stopping Power = 17.2 MeV/cm in W; Range (CSDA) = 0.00034 cm in W
 - Right after stripping, electron energy: 39.57 keV
- H⁻ Impingement at spatial peak, 0.234 mA current for 0.1-mm W wire

H⁻ beam at 04WS001 location; Jan 23 data

- Observed peak dq and dt ; average of 5.6- & 7.2-nC in 140 μ s, $N_{\text{avg}} = 1$, 4-Hz X 0.15-ms beam or 0.054 mA
 - Observed 10.5 mA_{pk} at TDCM001
 - Rms width: 1.73 mm (Hor) X 1.66 mm (Ver)
 - Observed current: 0.051 mA at spatial peak
 - Observation, ~105% current of Sternglass theory (compared to 0.049 mA)
 - Should be a “negative” distribution; electron flow vs. “conventional” flow



H⁻ beam at 10WS001 location, Nov 17, 2013 data, Sternglass theory for SE current



■ Initial H⁻ beam at CCL module #10 input: nom. 168.0 MeV

- Total: ~1 secondary electron for every 5.8261 incident H⁻ particles into W wire
- ~1 secondary electron for every 9.8371 incident protons (in H⁻ particles into wire)
 - Stopping Power = 50.82781 MeV/cm in W; Range (CSDA) = ~2 cm in W
- ~1 secondary electron for every 12.2888 incident electrons (in H⁻ particles into wire), however, 2 electrons per incident H⁻ particle are stripped and stopped in wire.
 - Stopping Power = 40.6873 MeV/cm in W; Range (CSDA) = 0.0013 cm in W
 - Right after stripping, electron energy: 91.396 keV



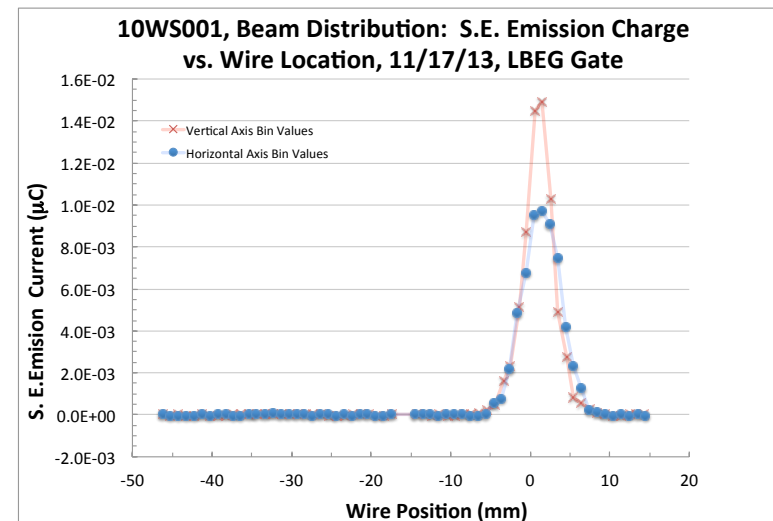
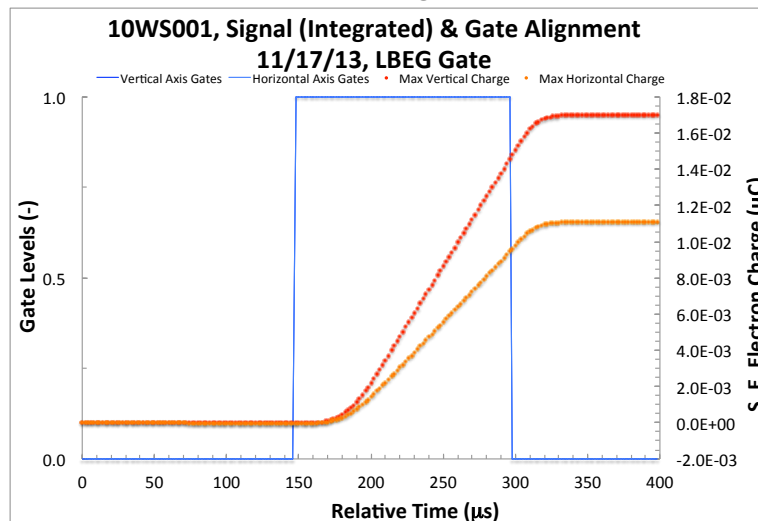
H⁻ Impingement at spatial peak, 0.1813 mA incident current, normalized to 10 mA.

2.33- X 2.07-mm (2.20 mm + projected round beam), 7.7-mA (14CM001), 4-Hz X

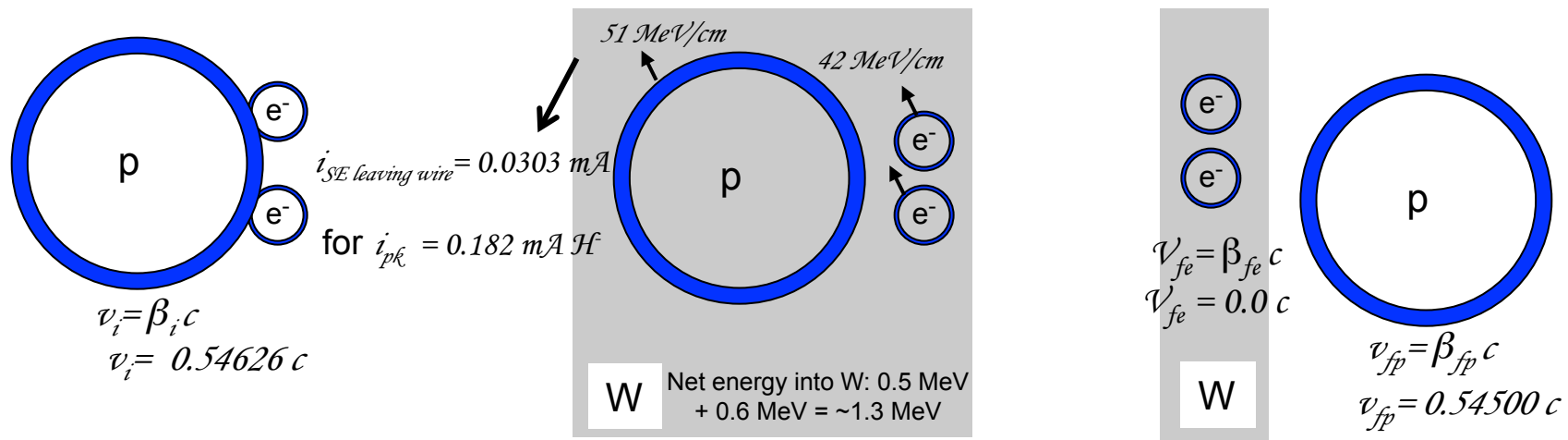
0.15-ms LBEG gated beam

H⁻ beam at 10WS001 location; Nov 17, 2013 data

- Observed peak dq and dt ; average of ~ 11.1 - & ~ 17.0 -nC in ~ 140 μ s, $N_{\text{avg}} = 1$, 4-Hz X ~ 0.15 -ms beam or ~ 0.10 mA
 - Observed $7.7 \text{ mA}_{\text{pk}}$ at 14CM001 [Normalized to 10 mA or 0.13 mA]
 - Rms width: 2.33 mm (Hor) X 2.07 mm (Ver)
 - Observed current: 0.13 mA at spatial peak
 - Observation, ~ 4.2 X current of Sternglass theory (compared to 0.0312 mA)
 - Should be a “negative” distribution; electron flow vs. “conventional” flow



H⁻ beam at 11WS001 location, Nov 17, 2013 data, Sternglass theory for SE current



■ Initial H⁻ beam at CCL module #11 input: nom. 182.1 MeV

- Total: ~1 secondary electron for every 6.0195 incident H⁻ particles into W wire
- ~1 secondary electron for every 10.4 incident protons (in H⁻ particles into wire)
 - Stopping Power = 48.2 MeV/cm in W; Range (CSDA) = ~2.3 cm in W
- ~1 secondary electron for every 12.342 incident electrons (in H⁻ particles into wire), however, 2 electrons per incident H⁻ particle stripped/stopped in wire. 14.34 electrons
 - Stopping Power = 40.513 MeV/cm in W; Range (CSDA) = 0.0015 cm in W
 - Right after stripping, electron energy: 99.07 keV

H⁻ beam at 11WS001 location; Nov 17, 2013 data

- Observed peak dq and dt ; average of 12.5- & 15.5-nC in 140 μ s, $N_{\text{avg}} = 1$, 4-Hz X 0.15-ms beam or 0.10 mA
 - Observed 7.5 mA_{pk} at 14CM001 [Normalized to 10 mA or 0.133 mA]
 - Rms width: 2.43 mm (Hor) X 1.96 mm (Ver)
 - Observed current: 0.133 mA at spatial peak, normalized
 - Observation, ~4.4X current of Sternglass theory (compared to 0.0303 mA)
 - Should be a “negative” distribution; electron flow vs. “conventional” flow

