Status of ECLOUD Simulations for the Shielded Button Measurements

I. Improvement in the simulation of e+ beam measurements

II. Properties of the macroparticles producing the button signal

III. Startling movies

IV. More information on the discrepancy for the e- beam measurements

V. Simulations for the witness bunch measurements

All material for this talk, including full sets of the analysis plots, may be obtained at www.lepp.cornell.edu/~critten/cesrta/ecloud/14apr10

-- 16 April: Added slide 13 showing effect of increasing the primary photoelectron energy from 5 eV to 40 eV --

Jim Crittenden

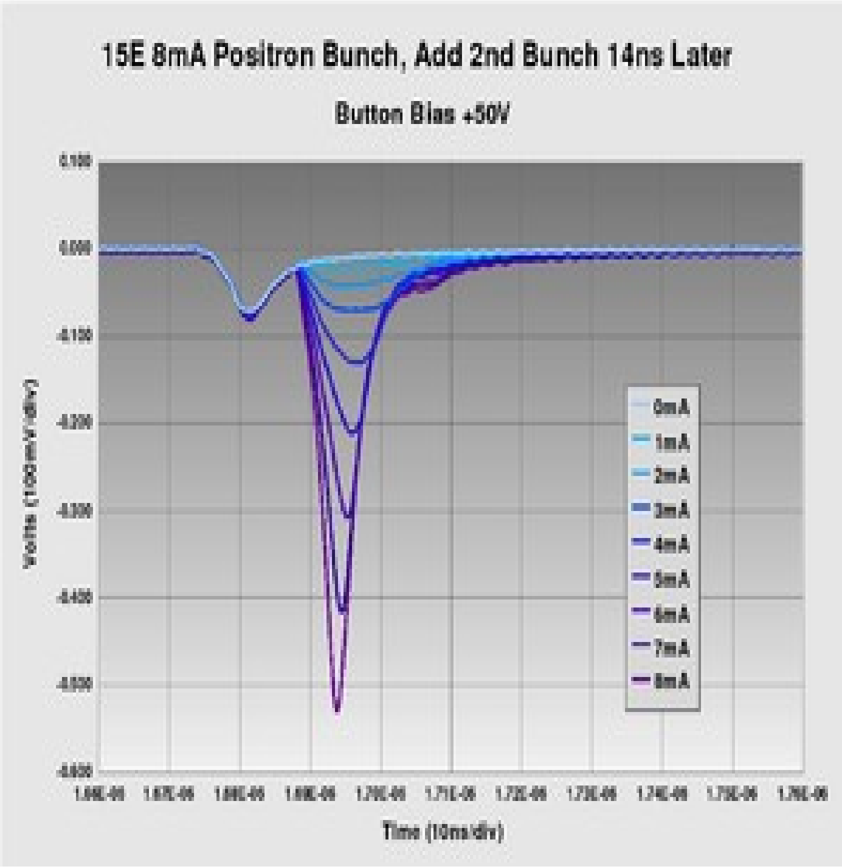
Cornell Laboratory for Accelerator-Based Sciences and Education

Electron Cloud Meeting

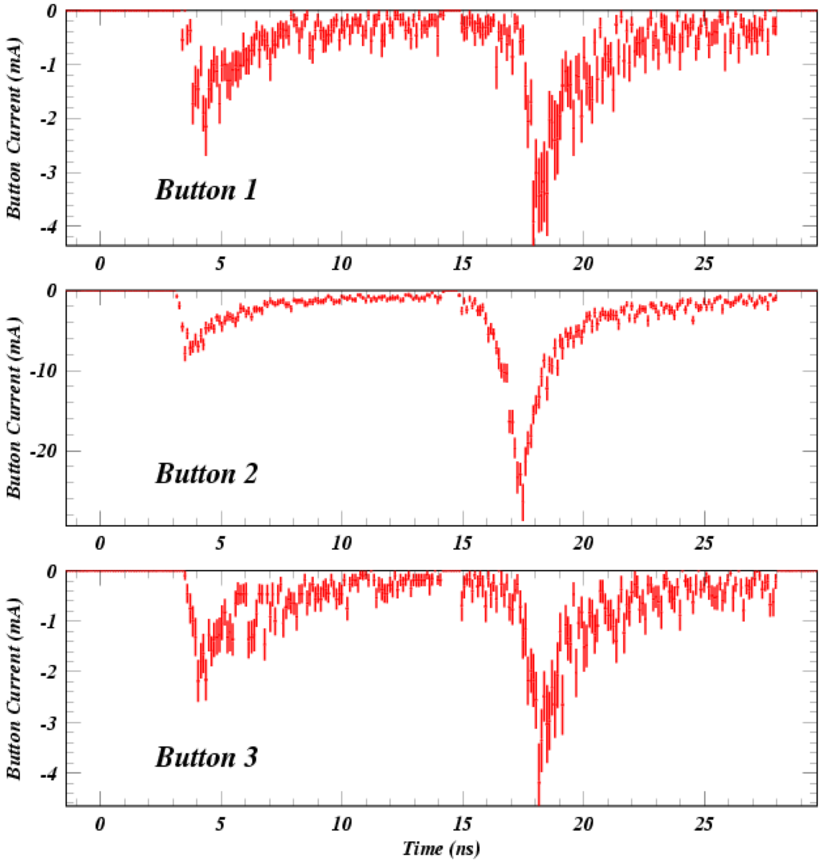
14 April 2010

Slide 6 of Last Week's Presentation
-- Positrons --

Measurement (Central Button)



ECLOUD Simulation

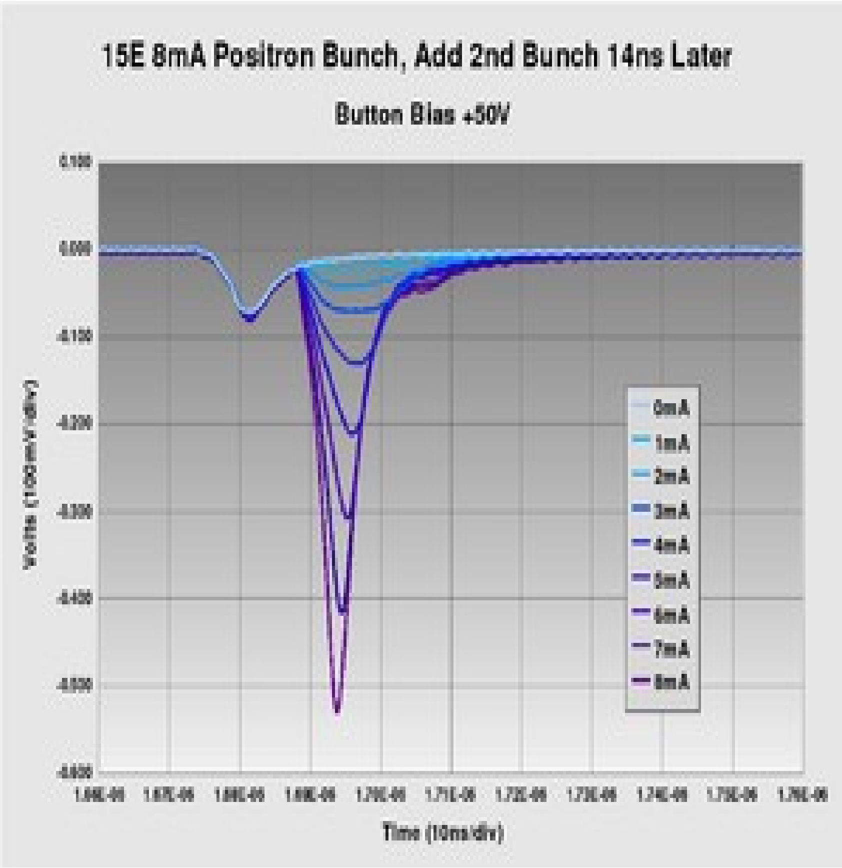


The ratio of the second peak in the button 2 signal to the first was only about a factor of four.

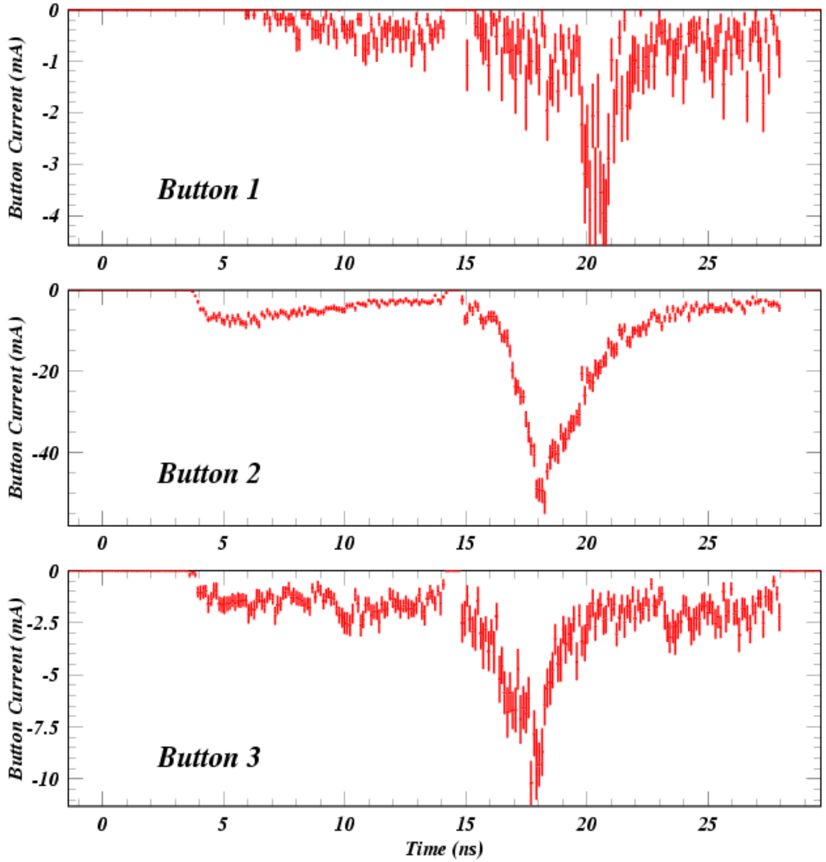
Cornell University
Laboratory for Elementary-Particle Physics

Introduction of the Horizontal Beam Offset
-- Positrons --

Measurement (Central Button)



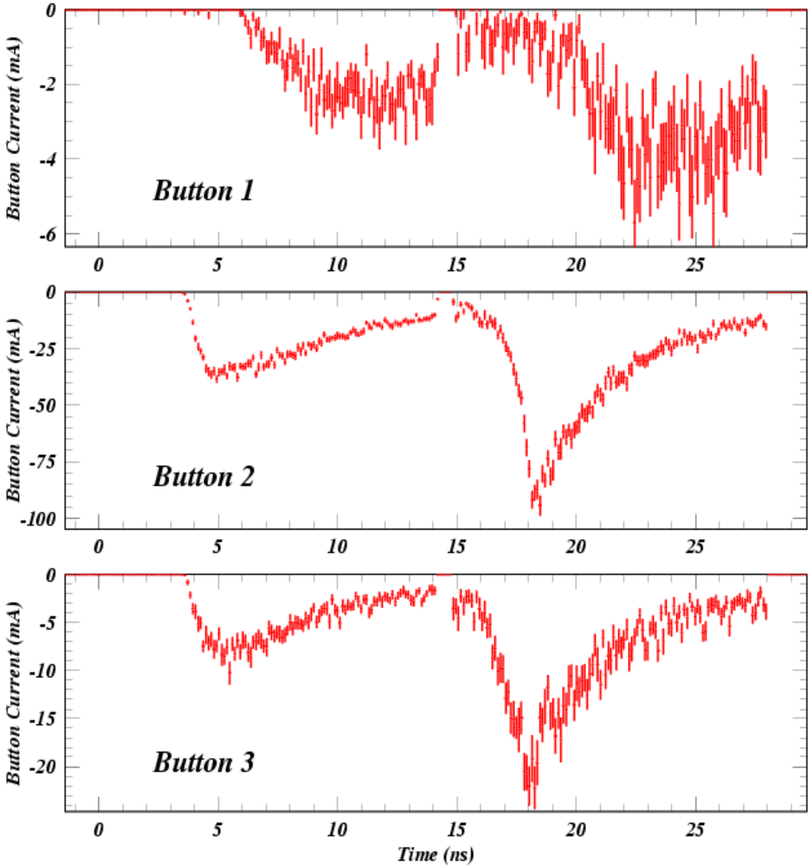
ECLOUD Simulation



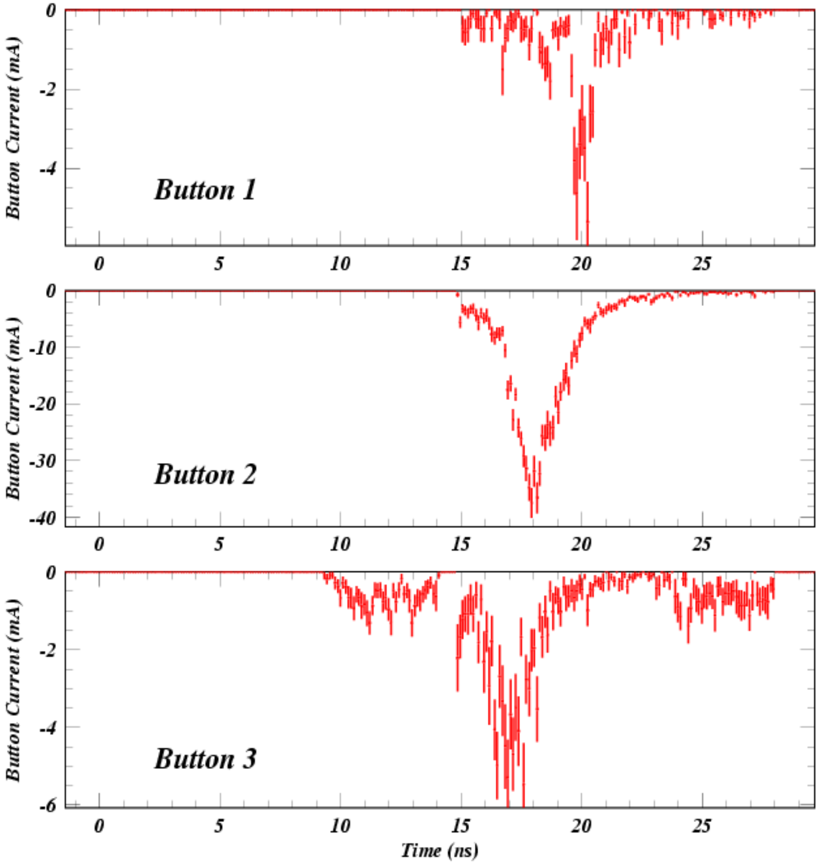
The ratio of the two peaks is much better reproduced when the 12 mm offset of the beam axis is included.

Dependence on the Reflectivity -- Positrons --

Reflectivity 100%



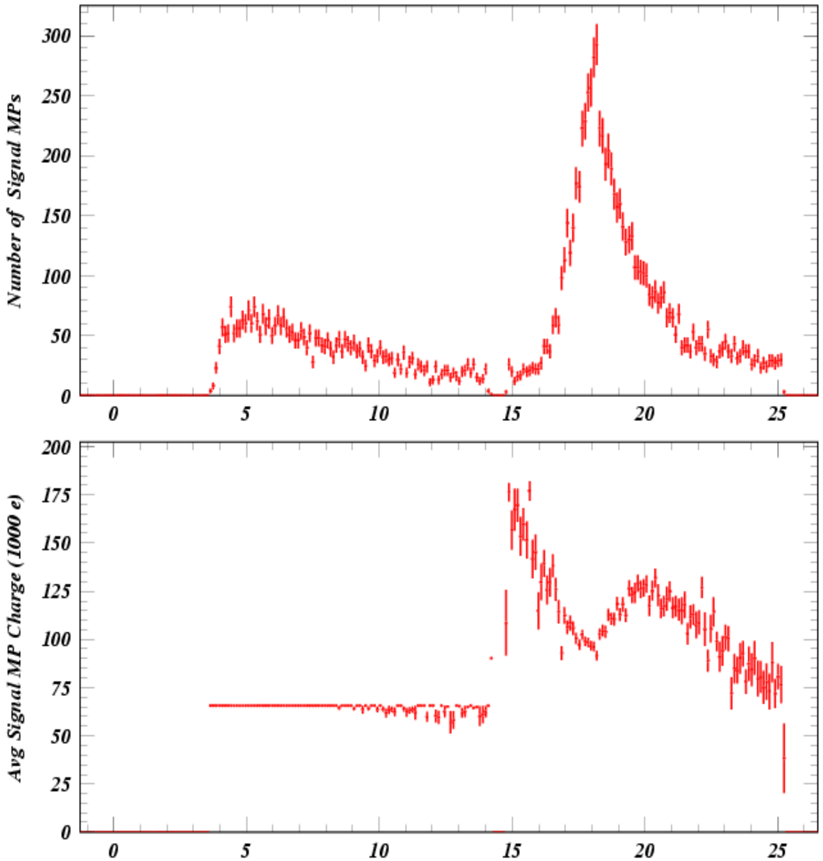
Reflectivity 0%



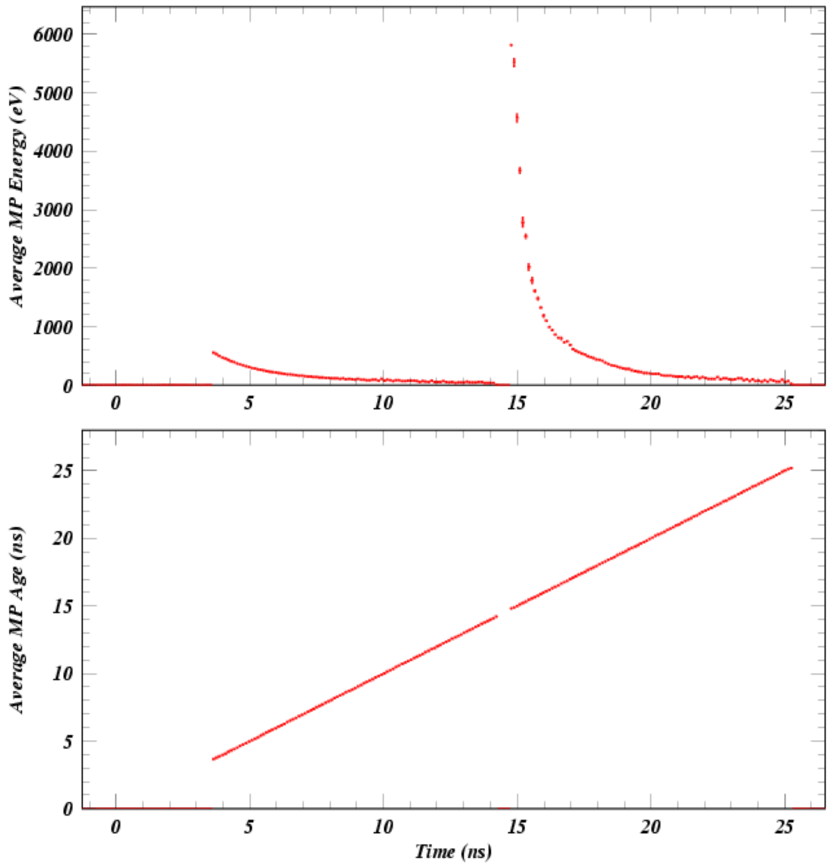
The ratio of the two peaks is sensitive to the azimuthal distribution of primaries.
The first bunch gives no button signal if no primaries are produced in the region of the shielded button.
A value for the reflectivity of 20% gives a good match to the measured ratio.

Properties of the Signal-producing Cloud Particles
-- Positrons --

Average Number and Charge

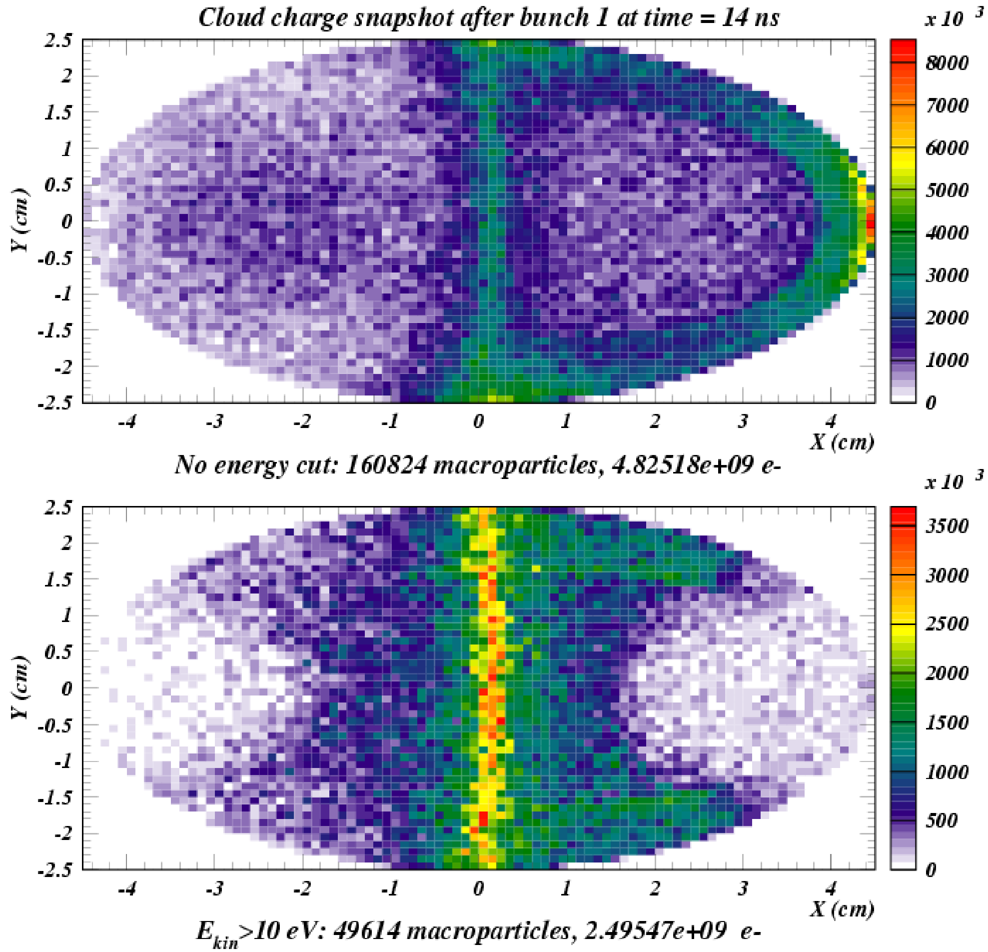


Average Energy and Age



Post-processing of 11k cloud macroparticles entering the detector. Averages over 0.11 ns are shown here.
Primaries are generated with the same charge value of about 65k e. The button signal is a convolution of macroparticle number and charge.
The bunch charge of 1.28e11 e (8 mA) is sufficient to generate kinetic energies of 6 keV during passage of the second bunch.

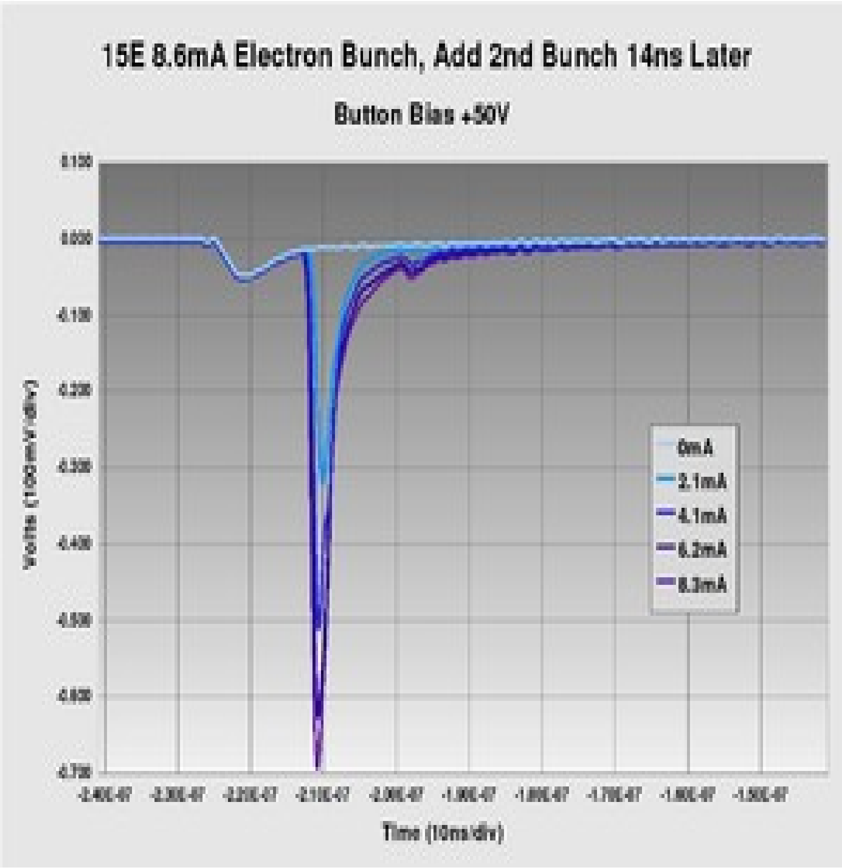
Cloud Snapshot Just Prior to the Passage of the Second Bunch
-- Positrons --



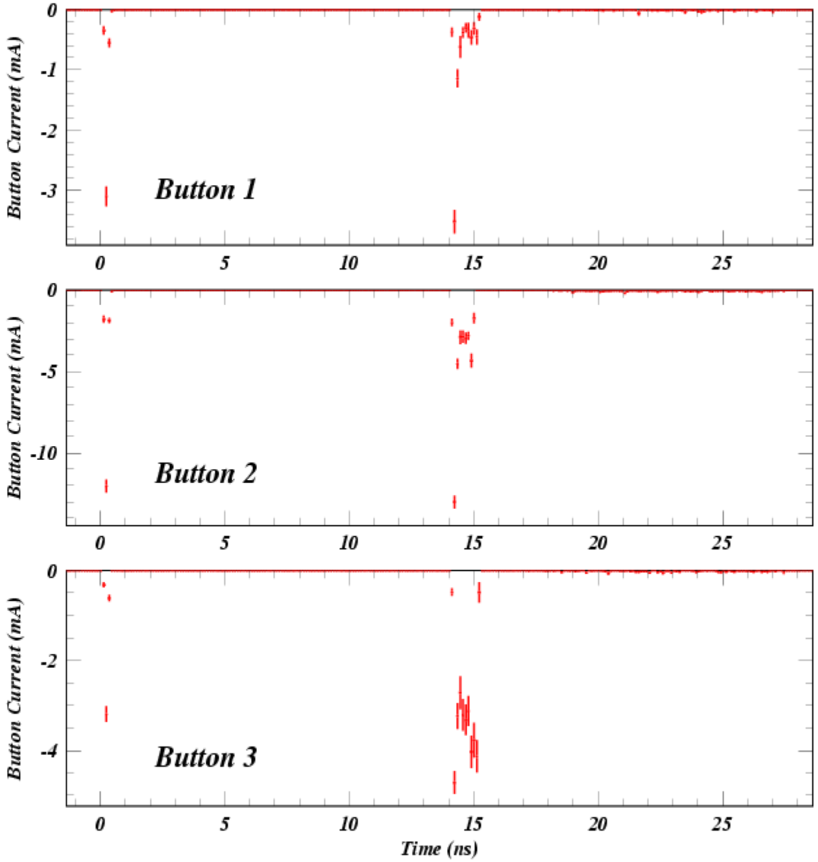
Unexpected result for the cloud snapshot at the arrival time of the second bunch.
A vertical stripe moving horizontally reaches the central button just as the second bunch arrives, as shown in the following movie.
The movie has 10 snapshots during the bunch passage and 40 snapshots between bunch passages.

Slide 7 of Last Week's Presentation
-- Electrons --

Measurement (Central Button)



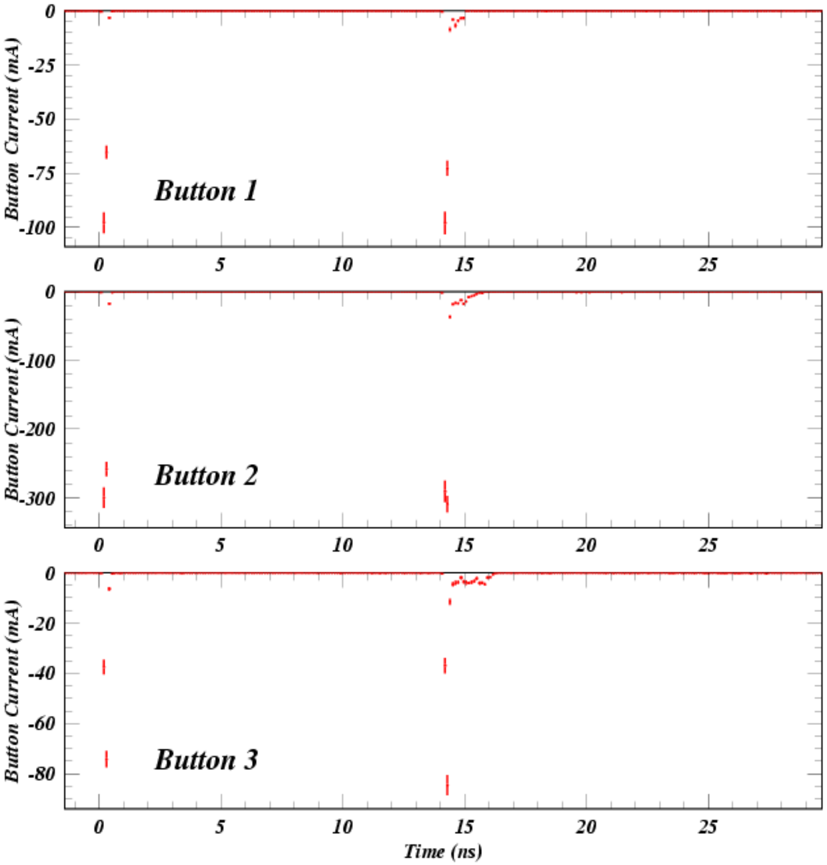
ECLOUD Simulation



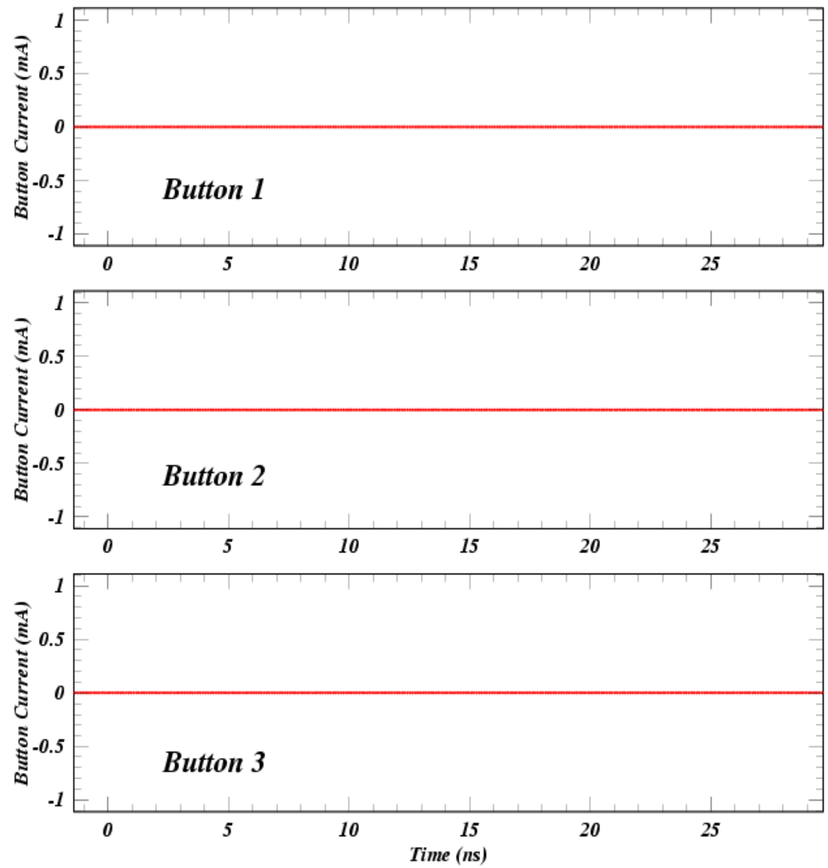
Today I will be brief on the simulation for the electron beam, because we don't yet understand it. However, I will show some important differences from the positron beam, and can quantitatively exclude one speculative source of the discrepancy in the time structure (mp transit time in the detector).

Dependence on the Reflectivity
-- Electrons --

Reflectivity 100%



Reflectivity 0%



The reflected-photon contribution accounts for ALL of the signal in the case of an electron beam.

ECLOUD input parameters

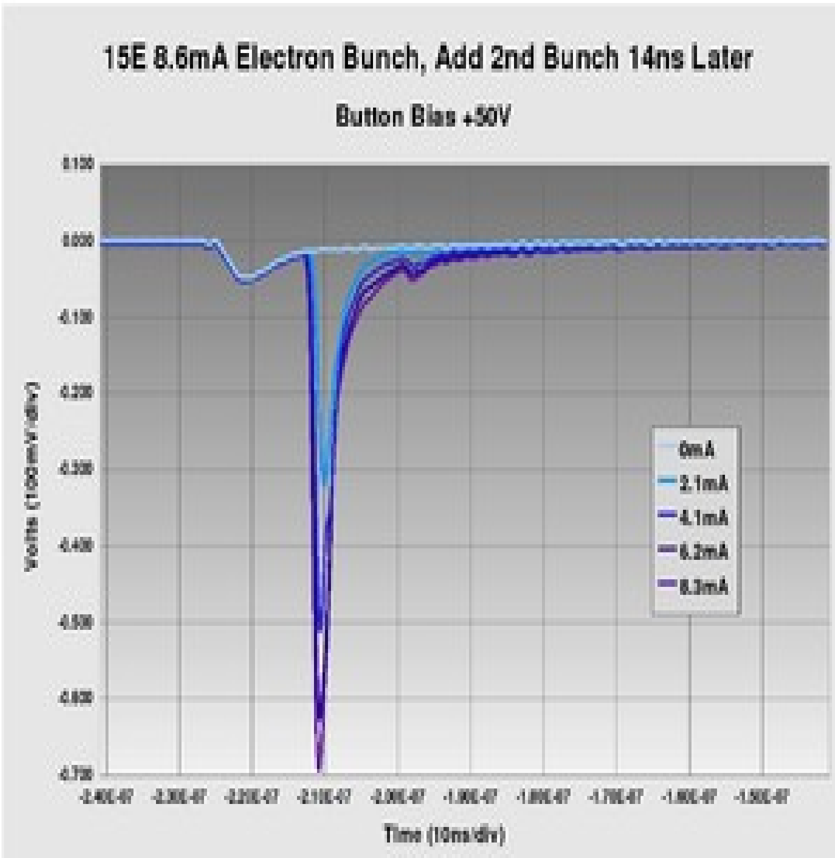
-- Modified to give equal reflected contributions for e+ and e- --

Bunch population	N_b	1.28e11 (8 mA)
Number of bunches	N_b	2
Bunch gap	$Ngap$	n.a.
Bunch spacing	$L_{sep}[m]$	4.2 (14 ns)
Bunch length	$\sigma_z\,[mm]$	e+: 18.8 e-: 18.8
Bunch horizontal size	$\sigma_x\,[mm]$	e+: 0.222 e-: 0.205
Bunch vertical size	$\sigma_y\,[mm]$	e+: 0.0185 e-: 0.0191
Photoelectron Yield	Y	0.1
Photon rate (γ / m / e)	dn_γ/ds	e+: 1.00 **e-: 0.3**
Antechamber protection	η	n.a.
Photon Reflectivity	R	e+: 20% **e-: 67%**
Max. Secondary Emission Yeld	δ_{max}	1.0 (0.9 t.s. & 0.1 rediff)
Energy at Max. SEY	$E_m\,[eV]$	400
SEY model	Cimino-Collins $(\delta(0)=0.5)$	

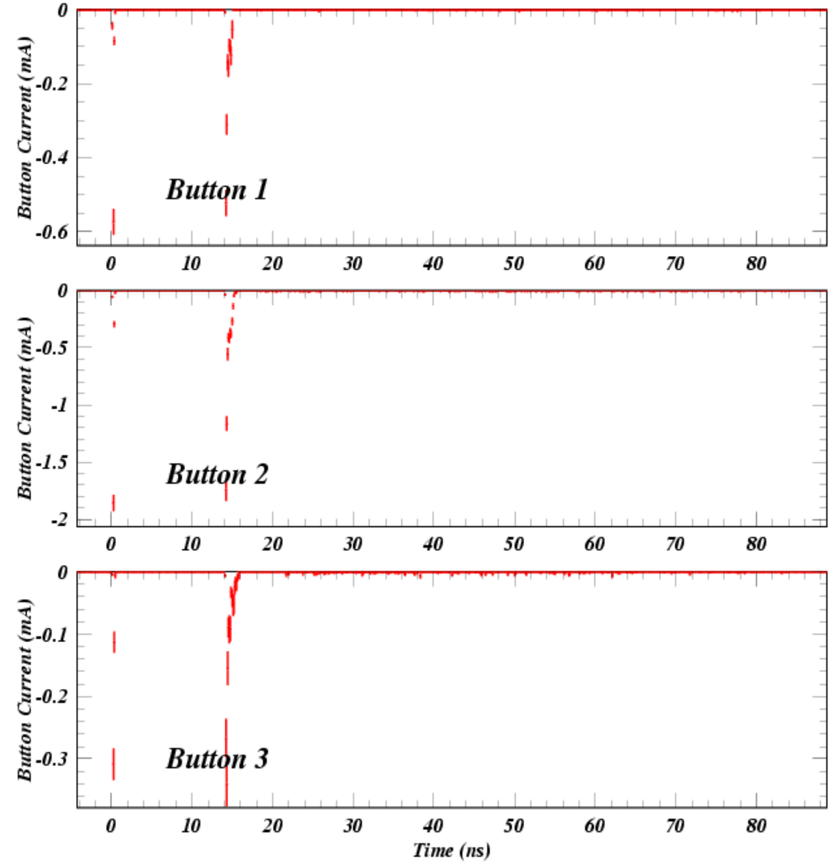
SEY estimated for processed TiN.
Numerical parameters large: 1000 steps, 101 kicks, 250k m.p. per bunch, 4000 steps between bunches.

Present Status of the Simulation for an Electron Beam, Including the 12-mm Horizontal Beam Offset

Measurement (Central Button)



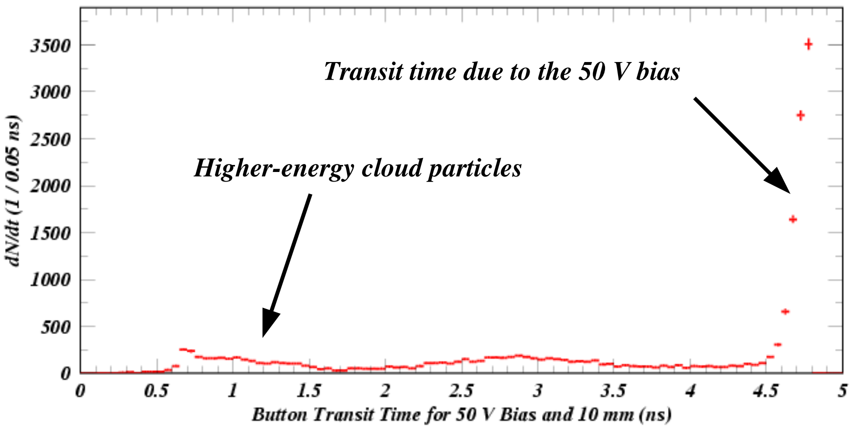
ECLOUD Simulation

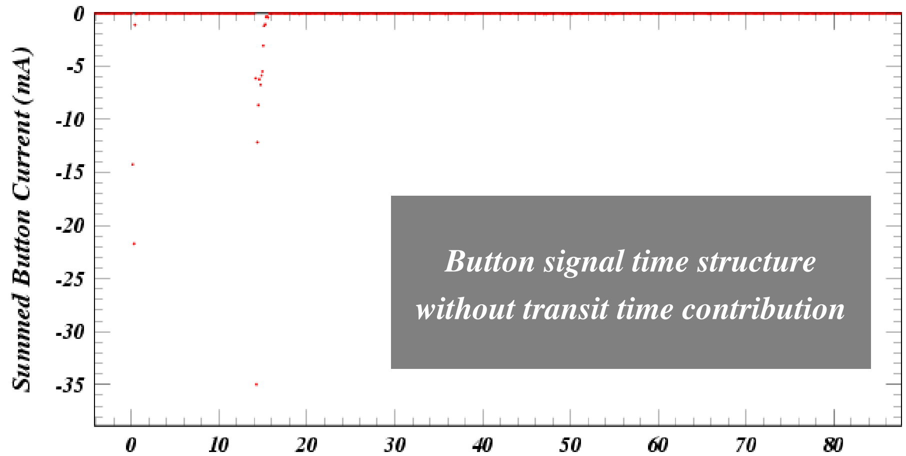


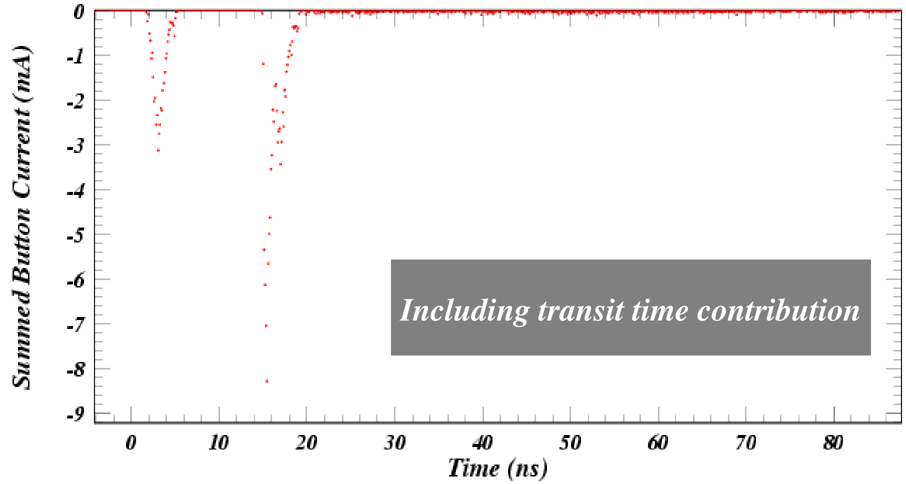
The simulated signal is prompt, and very brief, unlike the measurement.
In particular, where is the signal between bunches coming from the cloud self-repulsion?

Does the cloud kinetic energy distribution contribute to an arrival time spread at the button?

Transit time distribution
for 50 V bias and 10 mm button distance (overestimated)





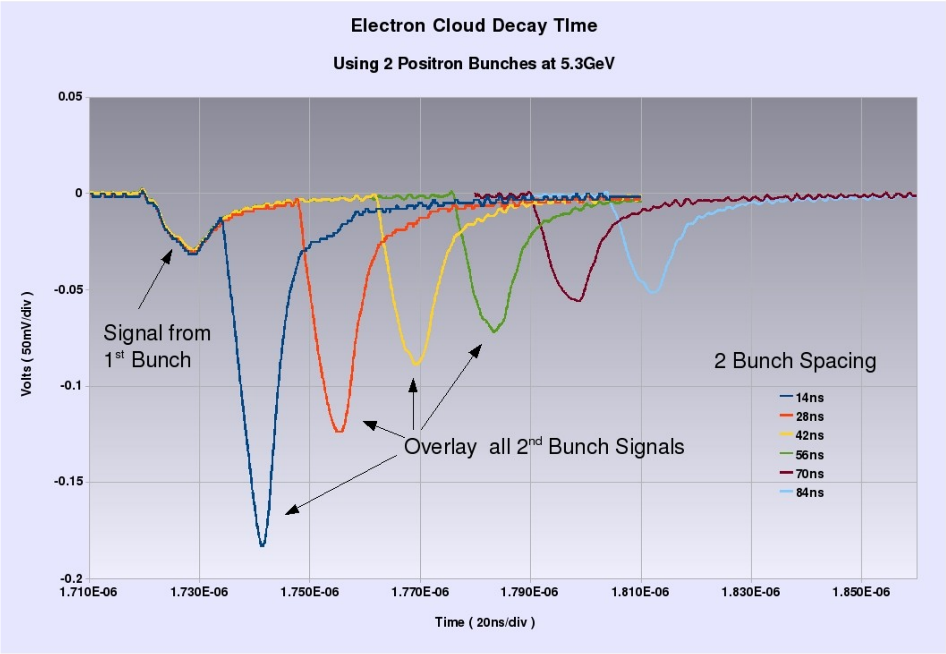


Postprocessing for 17.4k cloud particles.
The 50 V button bias dominates the contribution to the transit time.
Despite overestimating the distance to the button, the transit time spread cannot account for the signal time structure.

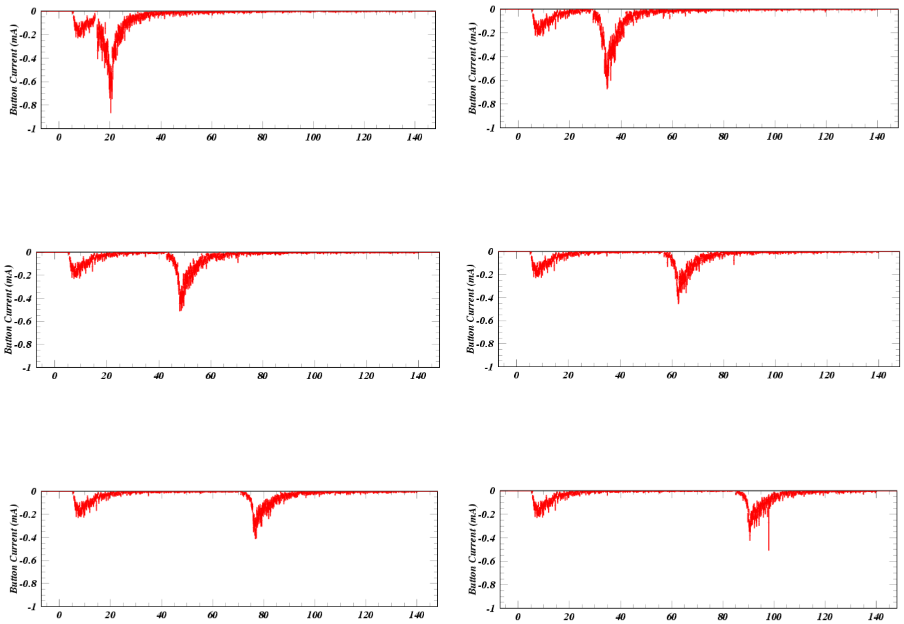
-- Cloud Lifetime Experiment --

See John Sikora's presentation at last week's machine studies meeting

Measurement (Central Button)



ECLOUD Simulation



The success of the simulation for a positron beam opens up a broad range of inquiry.
Will we be able to derive an estimate for δ(E=0) from such cloud lifetime measurements?

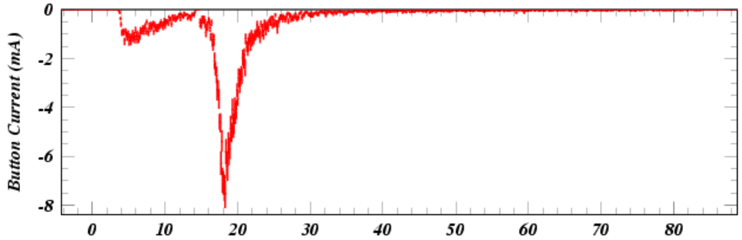
What is the effect of raising the energies of primary photoelectrons?

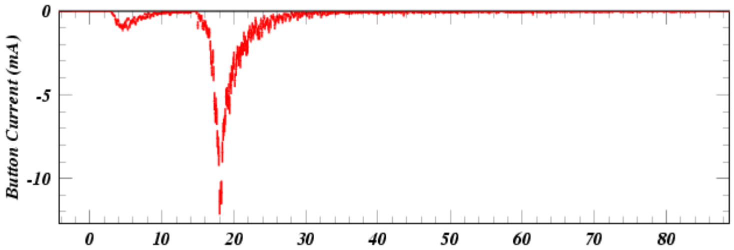
NB: The energy of an electron which travels 5 cm in 14 ns is 36 eV.

$E_{peak} = 5\ eV \quad \sigma_E = 5\ eV$
(ECLOUD default)

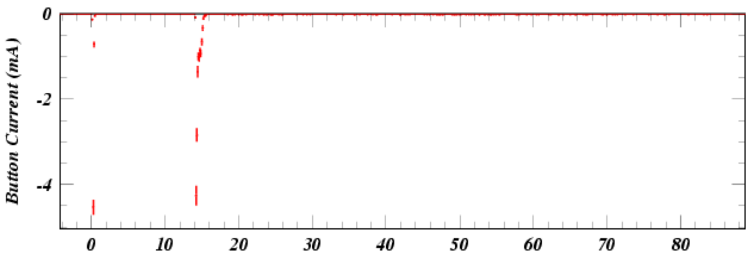
$E_{peak} = 40\ eV \quad \sigma_E = 20\ eV$

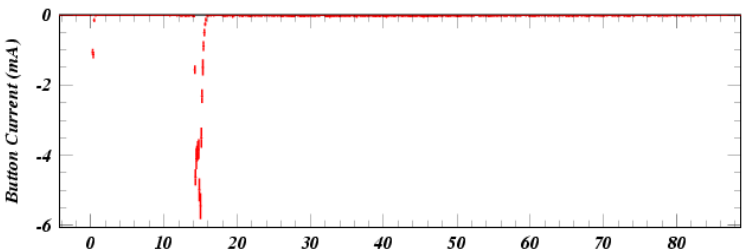
Positron beam





Electron beam





The energy distribution for primary p.e. is Gaussian with the negative tail omitted.
For higher-energy photoelectrons, the ratio of the two peaks is more consistent with the measurements for the electron beam and less similar for the positron beam.
The discrepancy between bunch passages for the electron beam remains to be resolved.