Cornell University
Laboratory for Elementary-Particle Physics

Present Status of ECLOUD Simulations of the Shielded Button Measurements of Electron Cloud Buildup at 15E

All material for this talk may be obtained at www.lepp.cornell.edu/~critten/cesrta/ecloud/4aug10

The measurements are described here: https ://webdb.lepp.cornell.edu/elog/CTA+MS/528 & 629 & 643

See also previous talks on simulations for the shielded button data on 4/21, 4/28, 5/12, 7/7, 7/14/2010

I. Full simulations for single-bunch (8 mA/bunch) e+ and e- beams with $B_{solenoid} = 0$ Gauss

II. Dependence on e- and e+ bunch currents (1.7 – 8.6 mA)

III. Dependence on $B_{solenoid} = 5 - 40$ Gauss for single-bunch e+ and e- beams with 1 mA/bunch

IV. Dependence on e- beam energy: 2.1 GeV ($E_{critical} = 0.34$ keV) versus 5.3 GeV ($E_{critical} = 5.61$ keV)

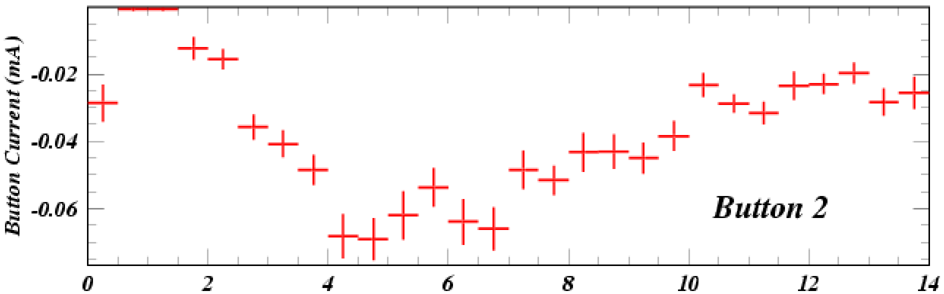
Jim Crittenden and Neboysa Omcikus

Cornell Laboratory for Accelerator-Based Sciences and Education

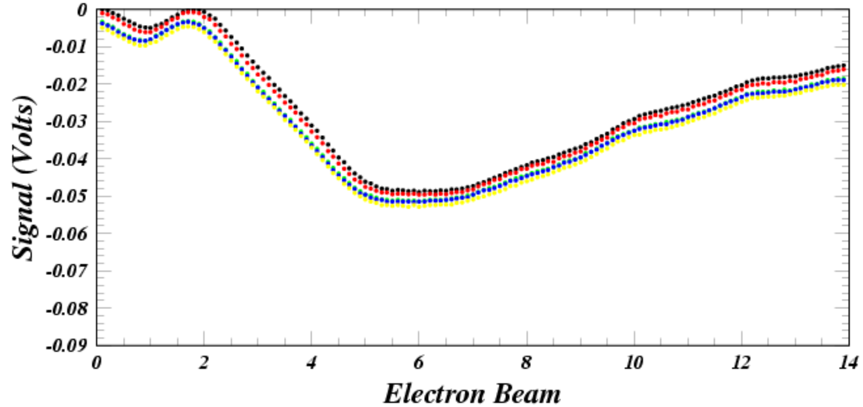
Electron Cloud Meeting

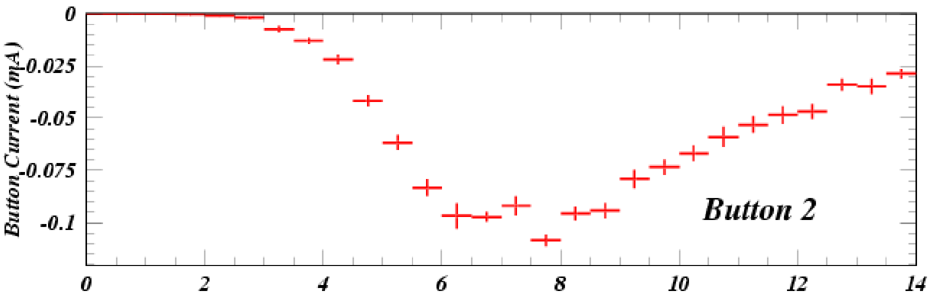
4 August 2010

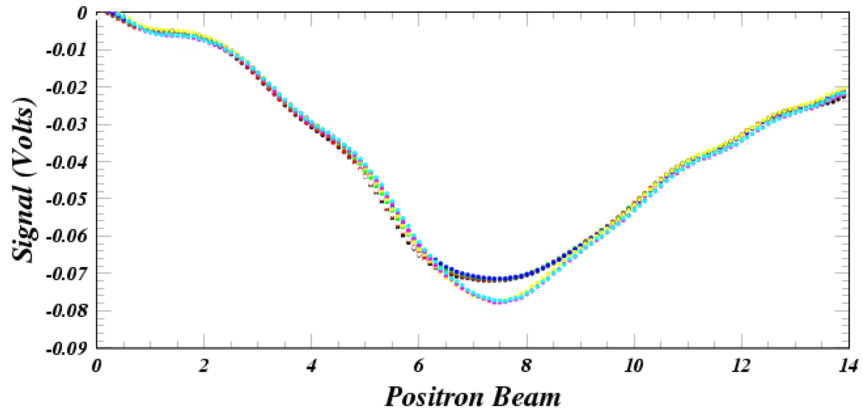
Recall Addendum 2 to talk on 7/14/2010
Updated ECLOUD simulation



15E (TiN) Shielded Button Measurements (3/16/2010, 5.3 GeV, 8 mA bunch)







The parameterizations of the photoelectron energy distributions have also been adapted to reproduce the signal shapes.
Values for the reflectivity of 20% and 33% for the e+ and e- beams respectively provide reasonable estimates of the relative e+ and e- shielded button signal magnitudes.

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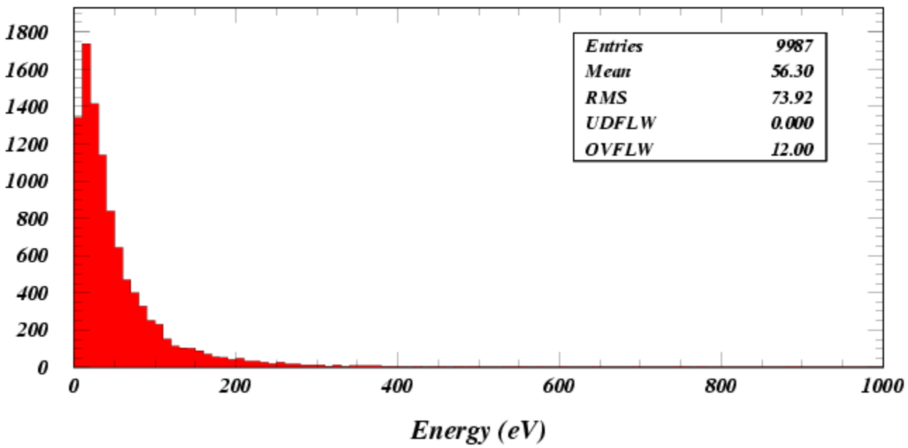
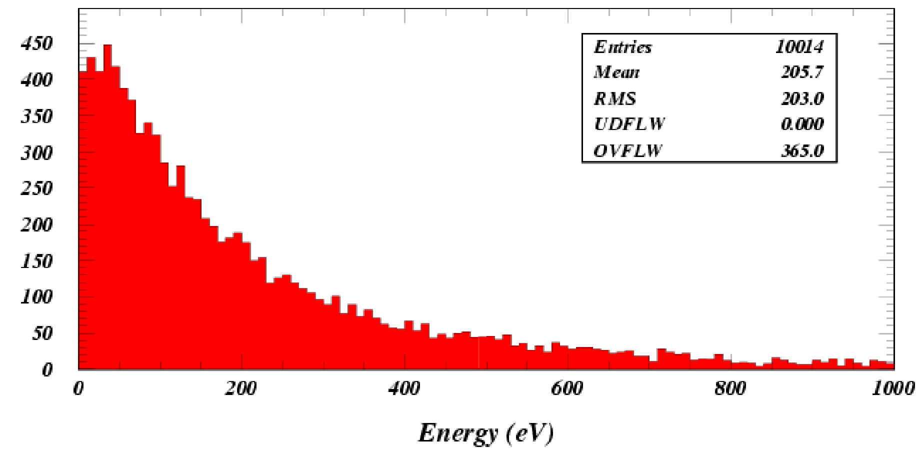
Addendum 3

ECLOUD Photoelectron Energy Distributions

Positron Beam



Electron Beam

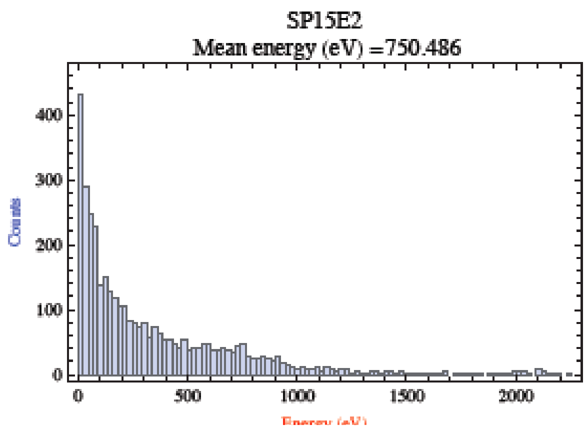


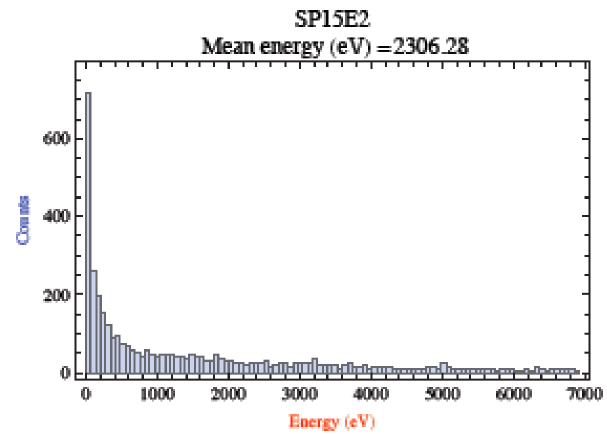
These are the photoelectron distributions which reproduce the measured shielded button signal shapes.
These include all generated photoelectrons, regardless of whether they contributed to the signal or not.
The photoelectrons which generate the shielded button signal originate on the bottom of the vacuum chamber.

Positrons

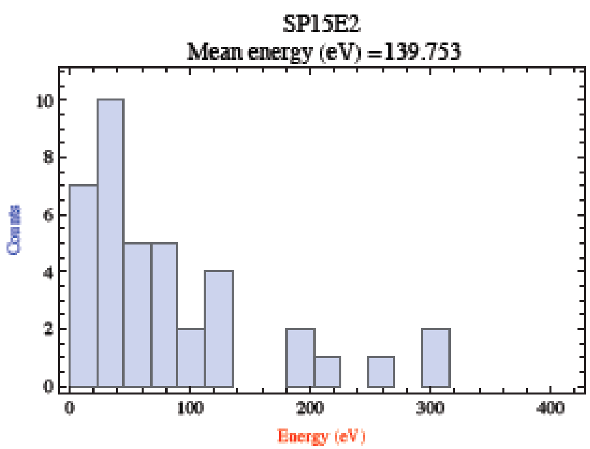
Electrons

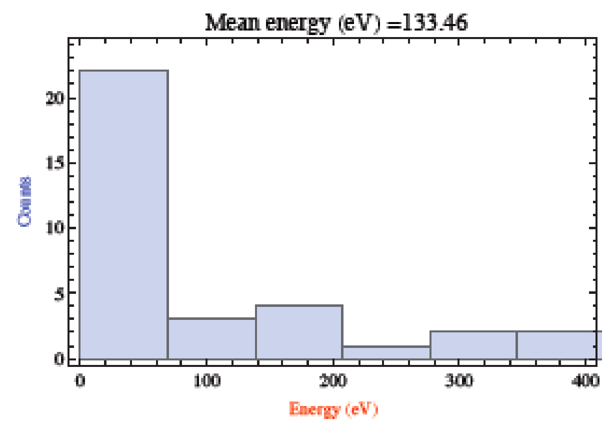
All photons





0.45<p<0.55
(top and
bottom only)



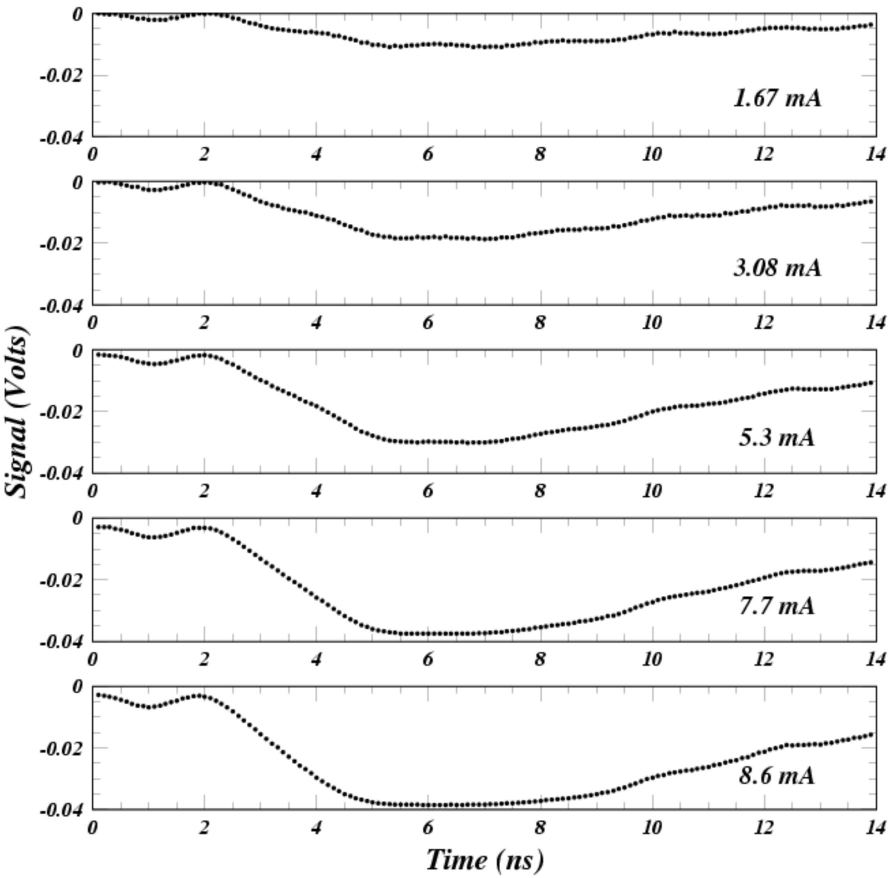


SYNRAD and SYNRAD3D roughly agree on the energy of the direct photons ($<E_\gamma> = 0.31\ E_{critical}$)

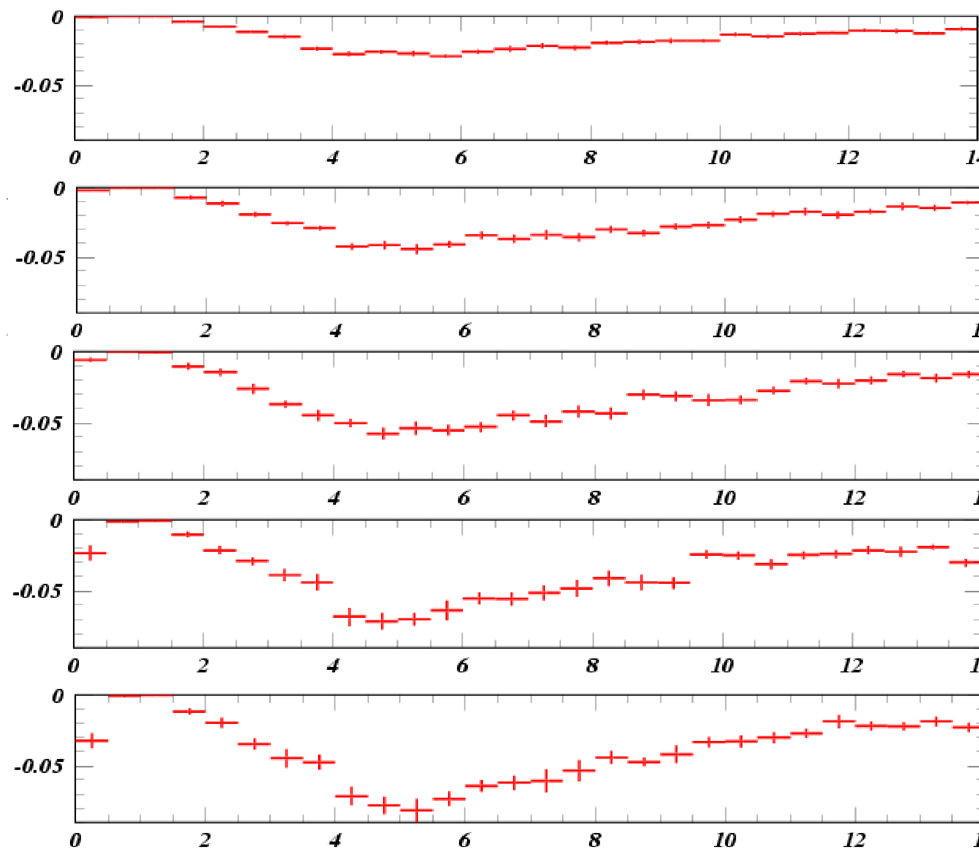
But SYNRAD3D apparently does not account for the high-energy component of the reflected-photon contribution.

Dependence on Electron Bunch Current

15E (TiN) SPU Measurements (3/16/2010, 5.3 GeV e-, Button 2)



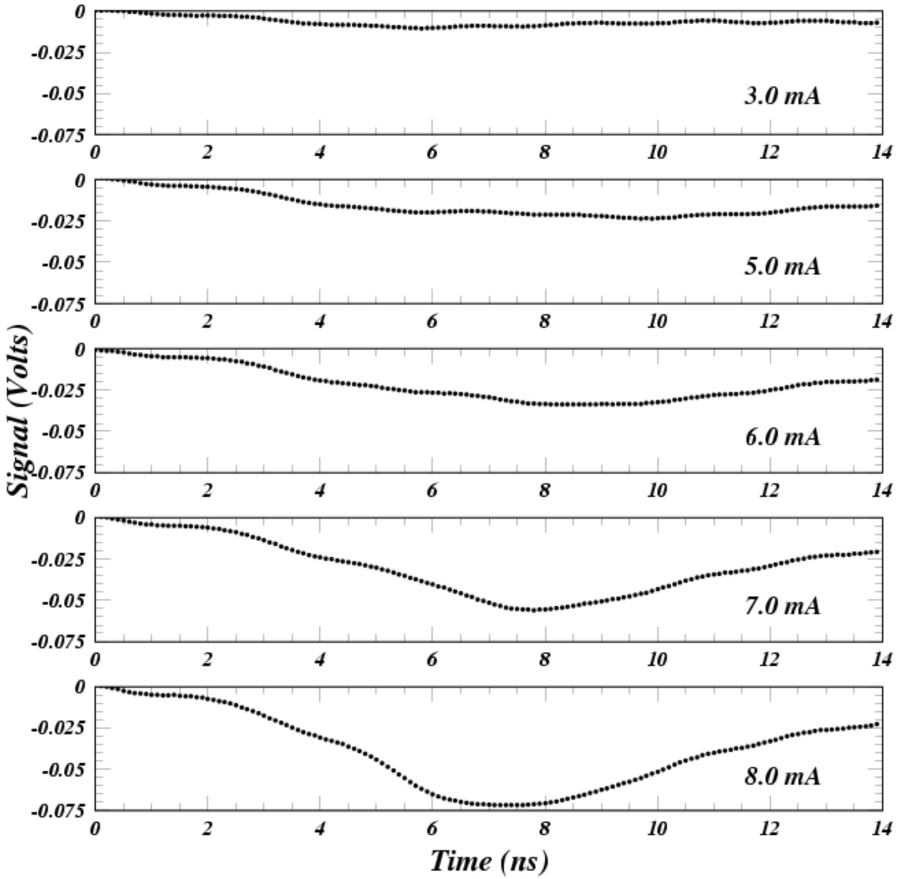
ECLOUD with updated photoelectron energy distribution



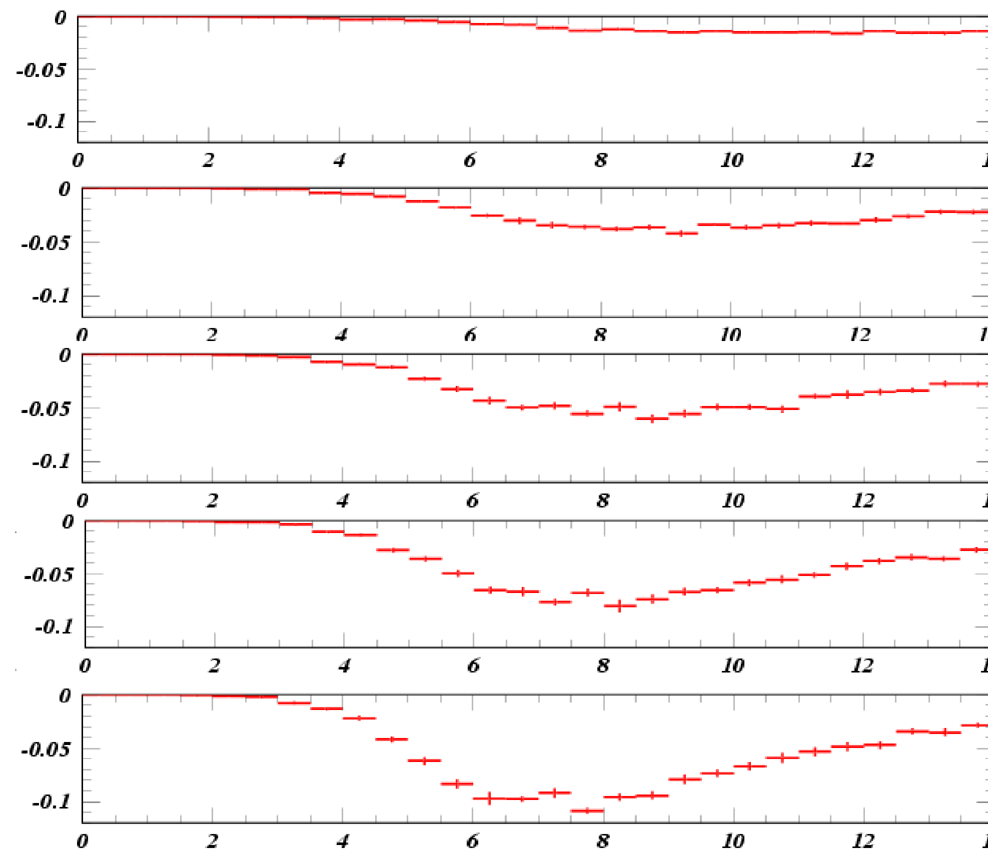
Time dependence insensitive to bunch current and cloud density (ρ = 0.9e12 –> 3.0e12 m^{-3}).
Magnitude dependence well modeled. Simulated arrival/production energy comparison shows space charge effect.
Prompt signal appears with higher bunch current, likely due to p.e. produced near the button.

Dependence on Positron Bunch Current

15E (TiN) SPU Measurements (3/16/2010, 5.3 GeV e+, Button 2)

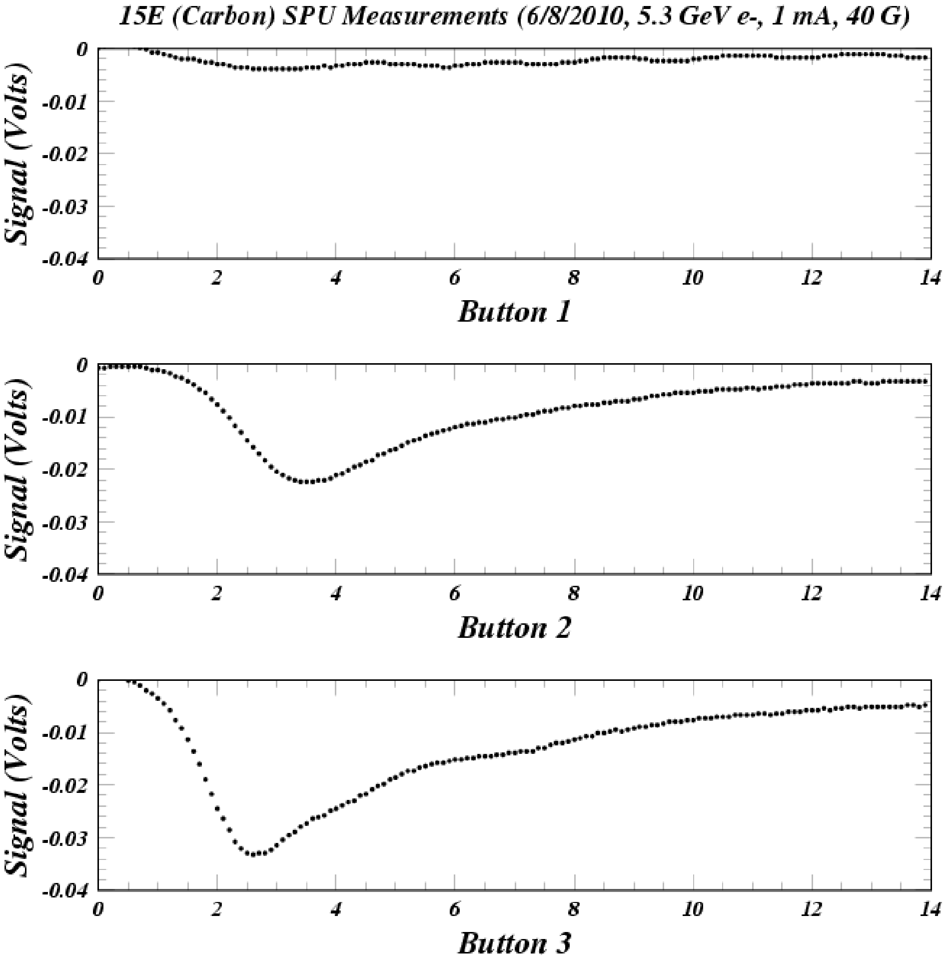


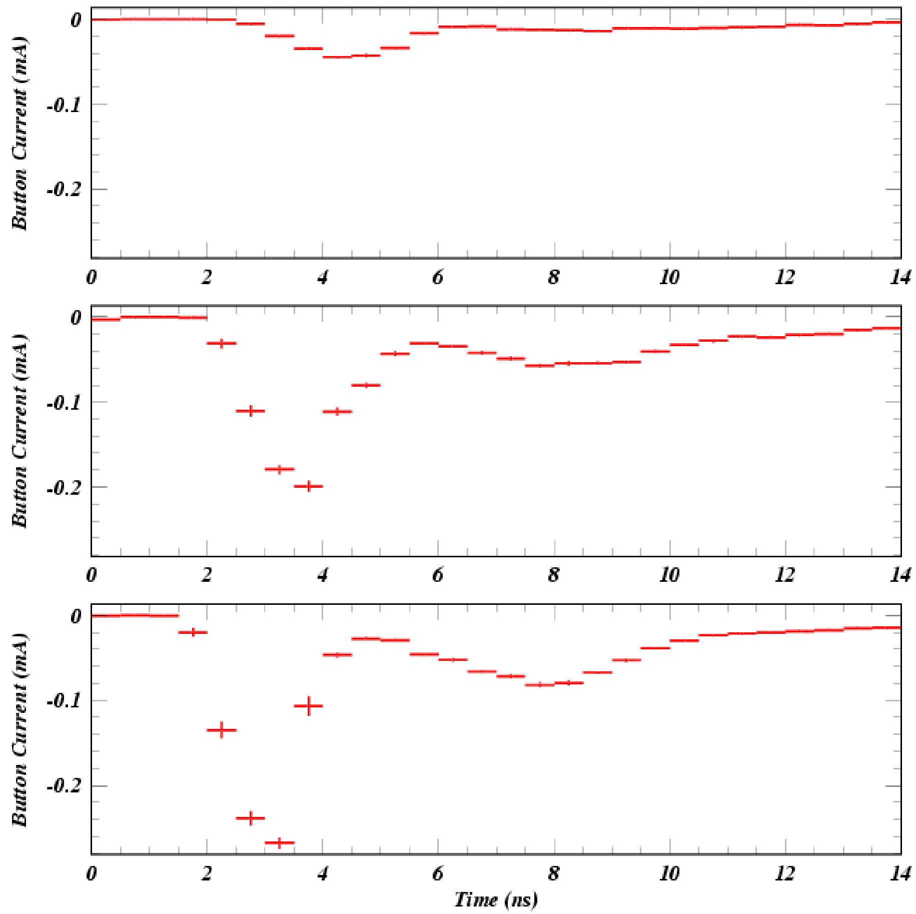
ECLOUD with updated photoelectron energy distribution



Time dependence IS sensitive to bunch current and cloud density (ρ = 0.5e12 –> 1.5e12 m^{-3}).
Magnitude dependence well modeled. Average p.e. production energy is 60 eV, rather than 430 eV for e- beam (8 mA).
No prompt signal for the positron beam.

Simulations with Solenoidal Field
- 5.3 GeV e-: now with realistic beam parameters -
- Photoelectron energy distribution from solenoid-off data -

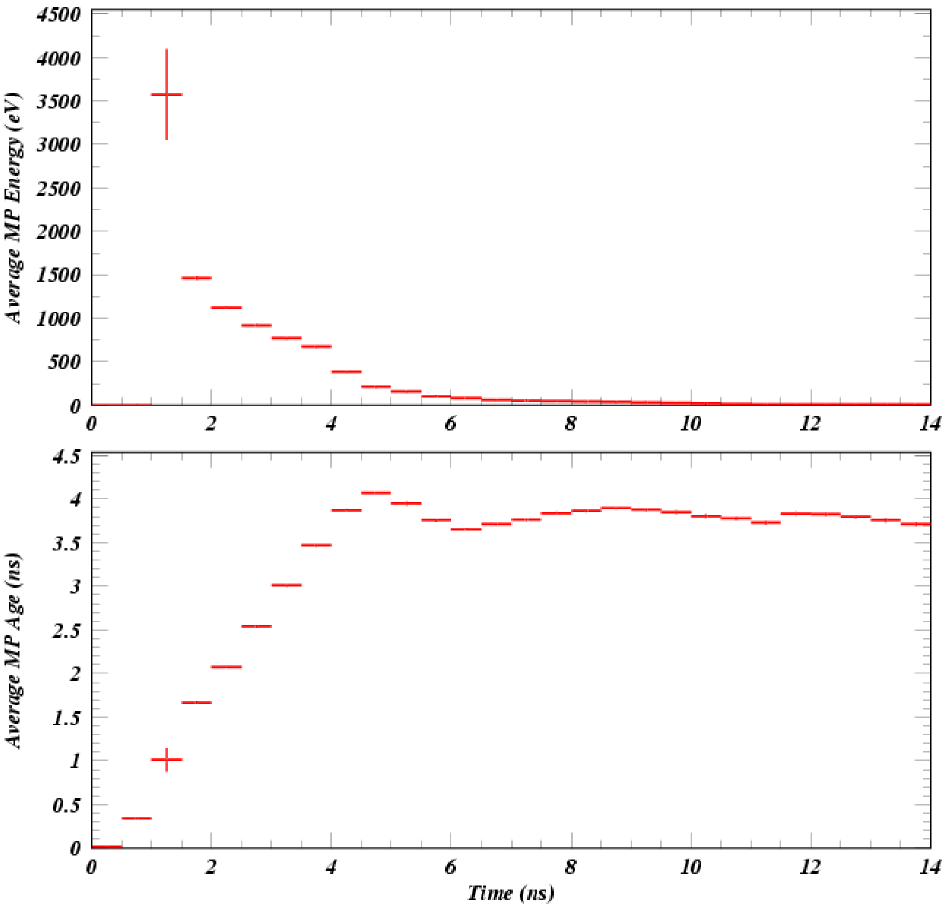




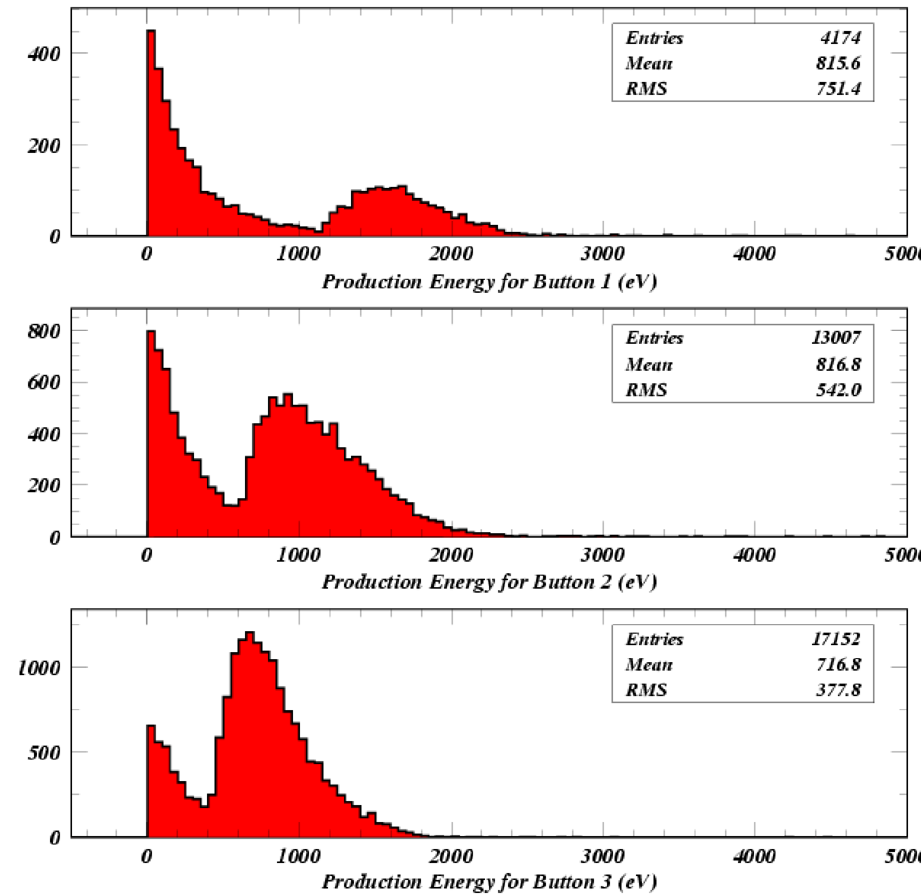
Primary source point is now at the outside edge of the vacuum chamber.
Rising edge well modeled with direct primaries. Falling edge due to secondaries.
Normalization of button currents not yet well defined.

Cloud macroparticles contributing to the button signals

Job 16643: Button Signal Macroparticles For 0 < T < 14 ns



Job 16643: Button Signal Energies For 0 < T < 14 ns: Primaries Only

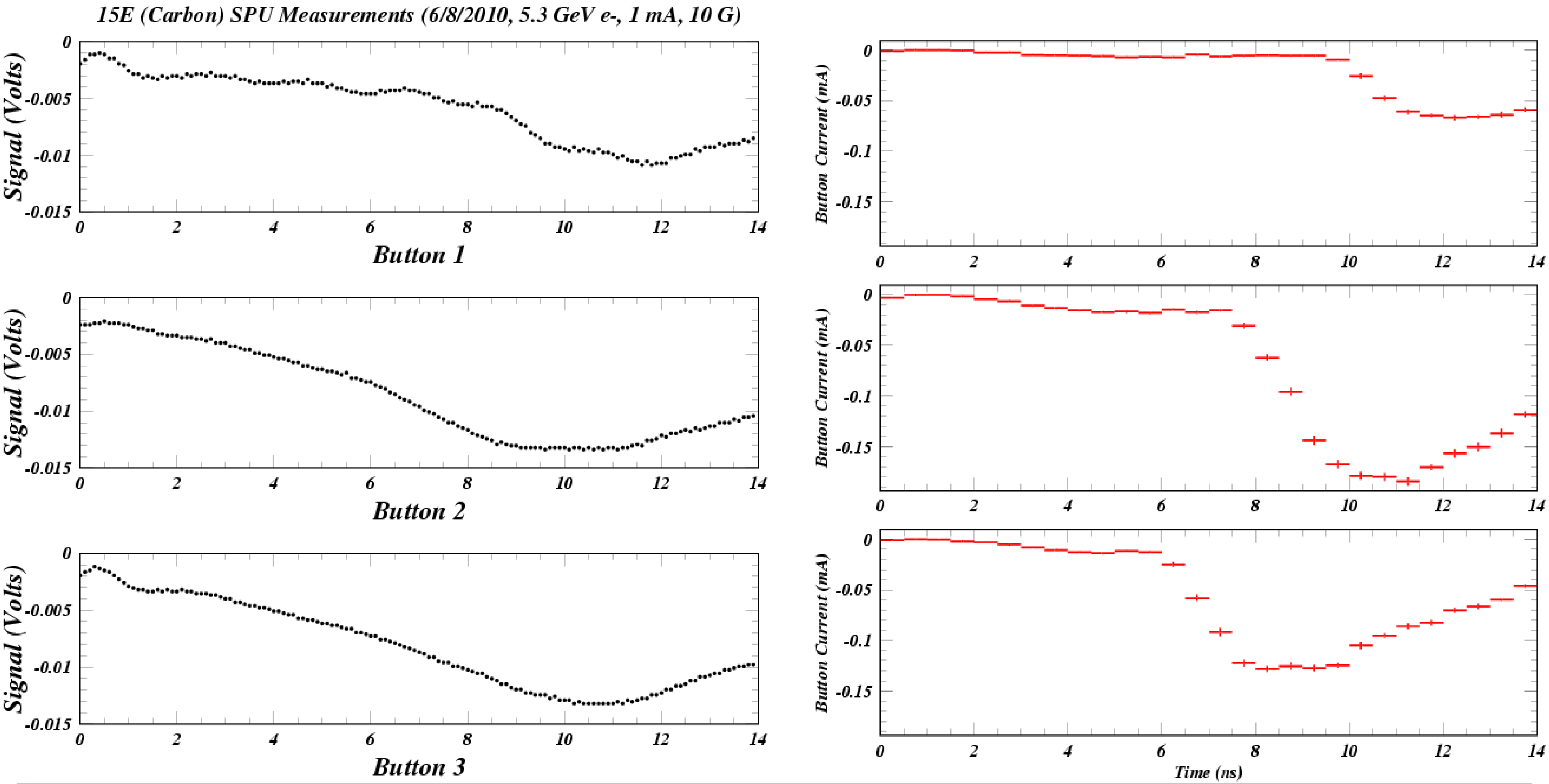


Macroparticle age vs cloud buildup time comparison shows that primaries dominate the signal up to 4 ns.

Energy acceptance of each button clearly shown.

Low-energy primaries due to production near buttons.

Simulations with Solenoidal Field
5.3 GeV Electrons
40 Gauss --> 10 Gauss



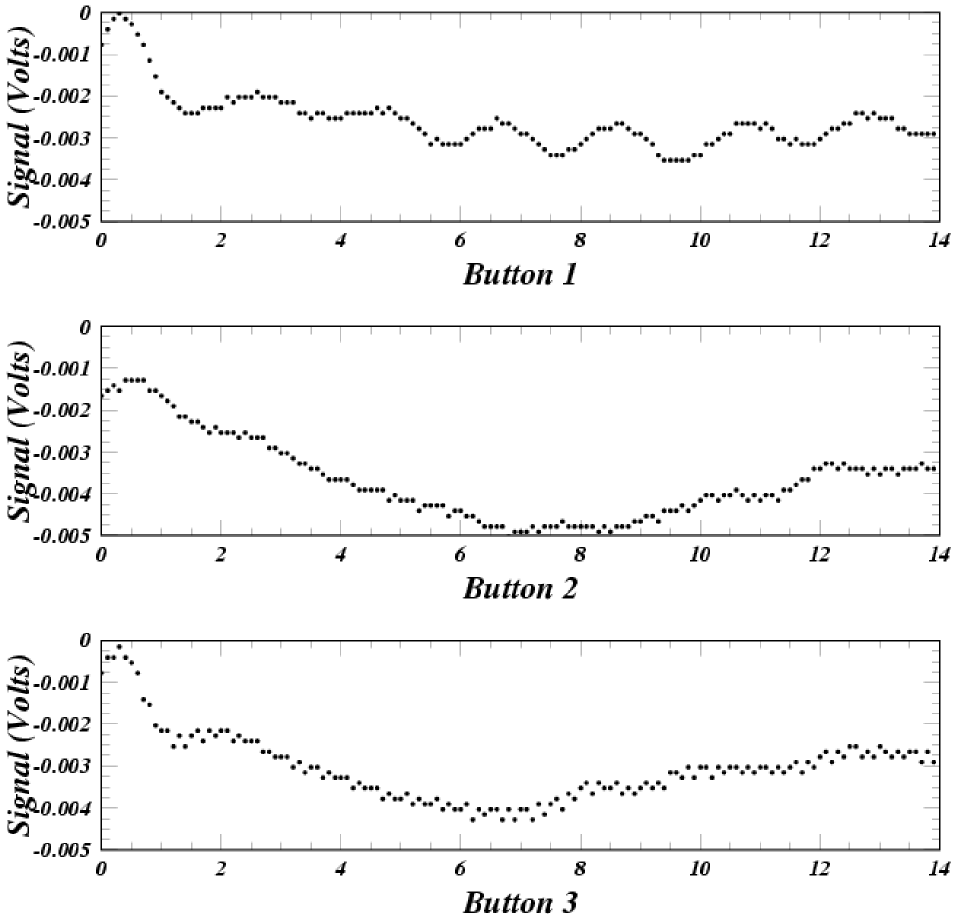
Later arrival times reasonably well modeled.

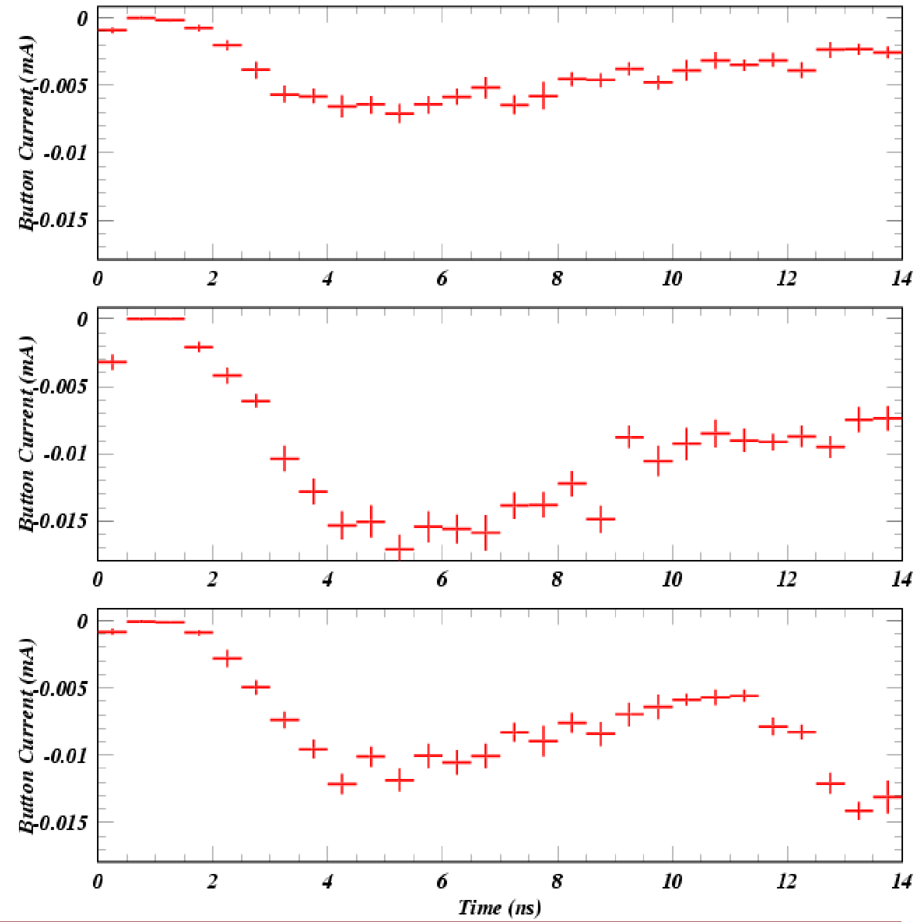
Signal macroparticles now much lower average energy: 175 (130, 100) eV for button 1 (2,3).

Adjusting energy distribution here will not affect the solenoid-off comparison.

Simulations with Solenoidal Field
5.3 GeV Electrons
10 Gauss --> 5 Gauss

15E (Carbon) SPU Measurements (6/8/2010, 5.3 GeV e-, 1 mA, 5 G)

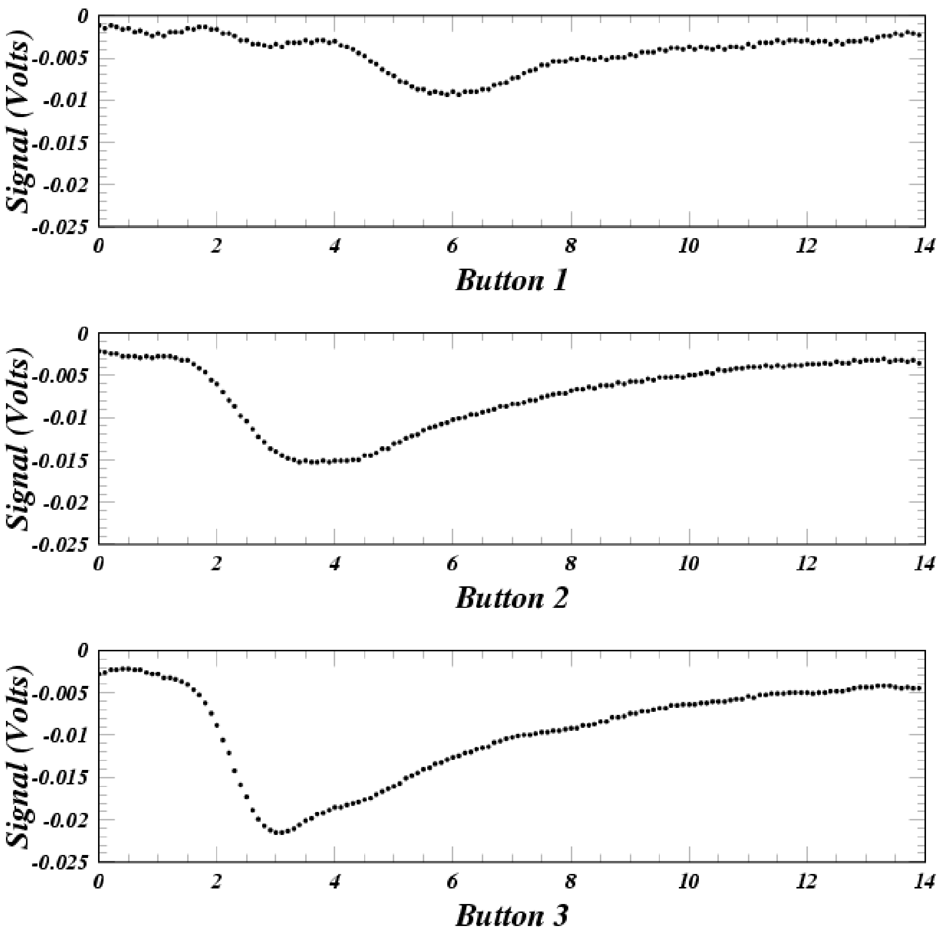


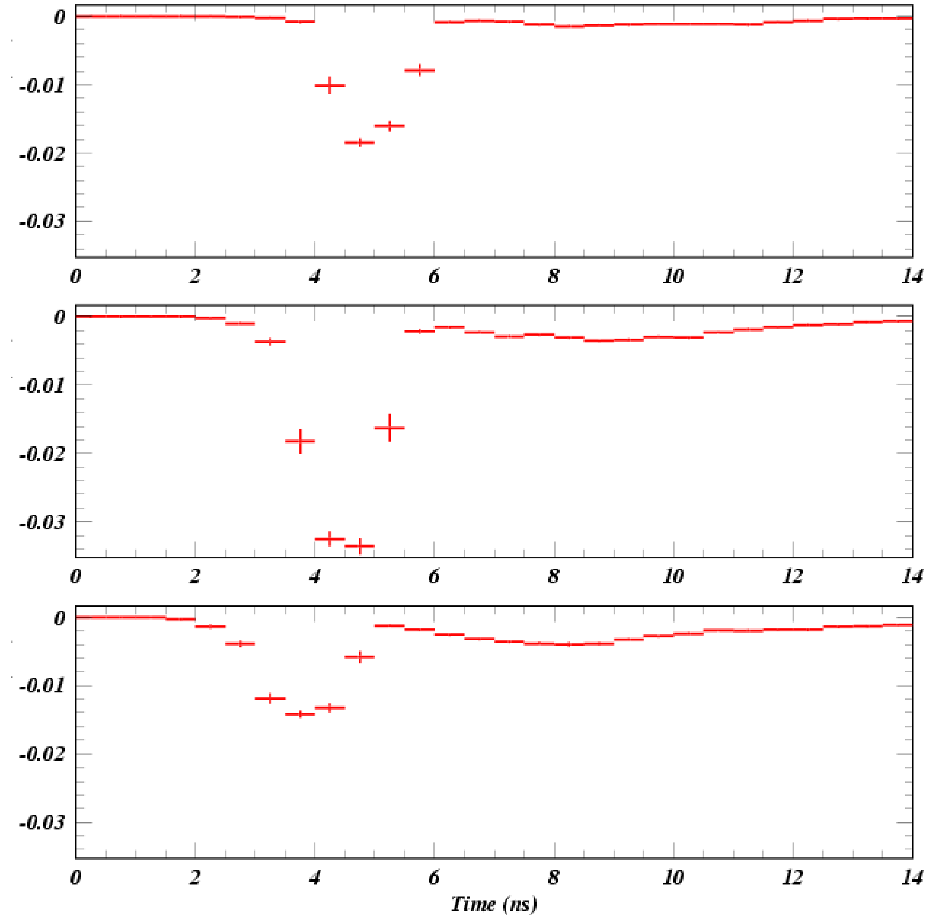


Motivated by Miguel's question concerning stray fields: Does the model work for small magnetic fields?
The relevant cloud dynamics is now more complicated. The simulated signals are an order of magnitude lower, and the average mp energy is now much higher: 270-390 eV. More study needed.

Simulations with Solenoidal Field
5.3 GeV Positrons
40 Gauss

15E (Carbon) SPU Measurements (5/17/2010, 5.3 GeV e+, 1 mA, 40 G)





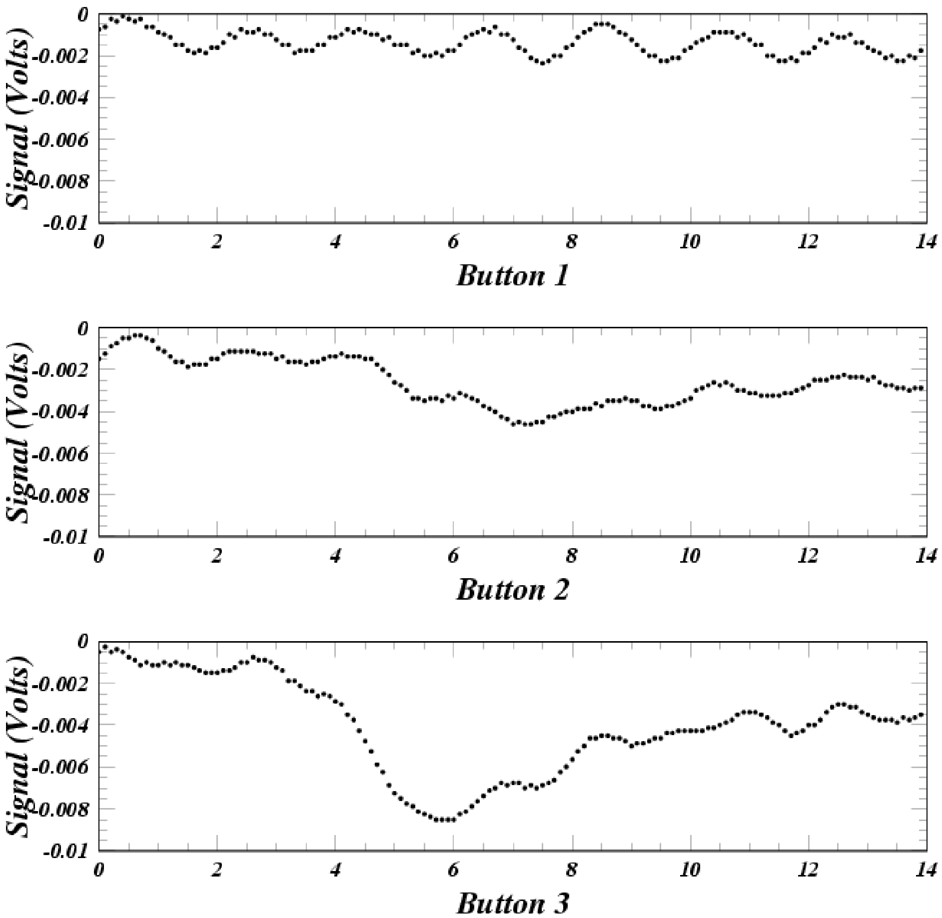
Time development not as well modeled as for the electron beam.

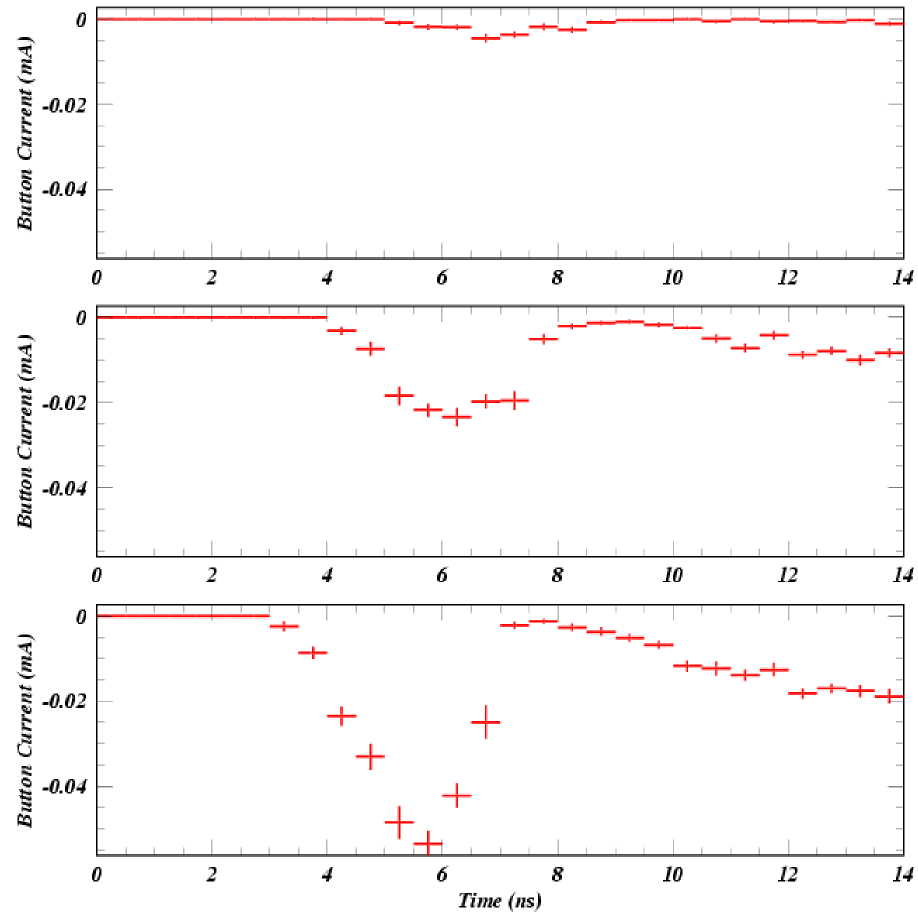
Signal macroparticles are lower average energy: 71 (101, 192) eV for button 1 (2,3) owing to the attractive beam kick.

This inconsistency may indicate different energy distributions for direct and reflected photons.

Simulations with Solenoidal Field
2.1 GeV Electrons ($E_{critical}$ = 340 eV !)
20 Gauss

15E (Carbon) SPU Measurements (5/19/2010, 2.1 GeV e-, 1 mA, 20 G)





The simulation shows these signals to be clean samples of direct primaries.
In fact, we had to remove the 33% reflected contribution to get reasonable agreement, removing an early contribution from nearby production.
Signal macroparticles have average energy: 414 (275, 200) eV for button 1 (2,3) for 20 Gauss.
Since the signals disappear entirely at 5 and 40 Gauss, we can scan the entire energy distribution at 2.1 GeV using fine field steps.

The work continues ...

Further tuning of the photoelectron energy distributions is likely to be fruitful.

Can these distributions be reconciled with the advanced simulations of coherent tune shift measurements?
Will we need to add a low-energy gaussian contribution?

All the results presented here stop the comparison prior to the passage of a second bunch, but both simulation and measurements are available. This comparison will provide information on the cloud development, but is likely to require code development for secondary production near the detectors.

The above development is prerequisite to the witness bunch measurements we plan to use to provide information on the simulated cloud lifetime and constrain the elastic yield parameter.

Can these measurements serve to constrain the SYNRAD3D reflection model?

Is there life after Neboysa?