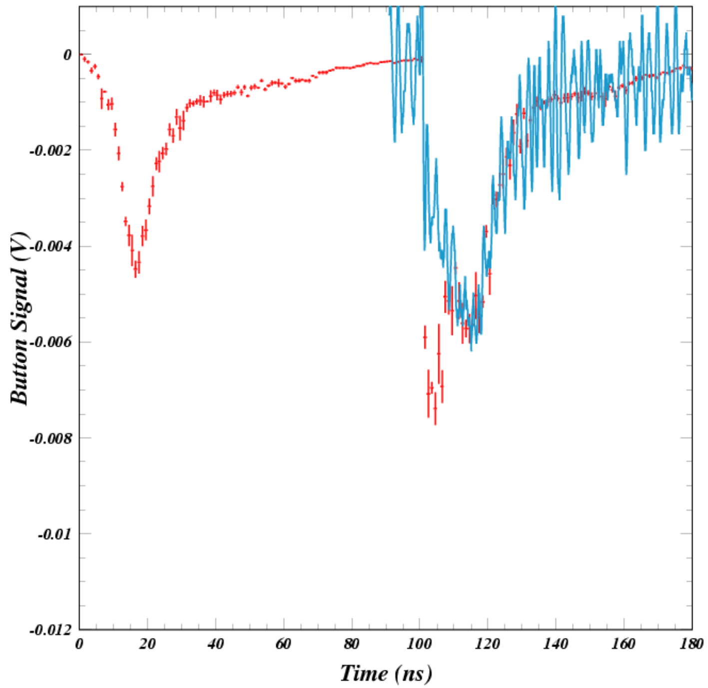
Cornell University
Laboratory for Elementary-Particle Physics

Breakthrough in the Modeling of the Shielded Pickup Measurements – Introduction of the Arrival-Energy Weight Function –

Resolves the beam position puzzle
Resolves the bunch current dependence conundrum



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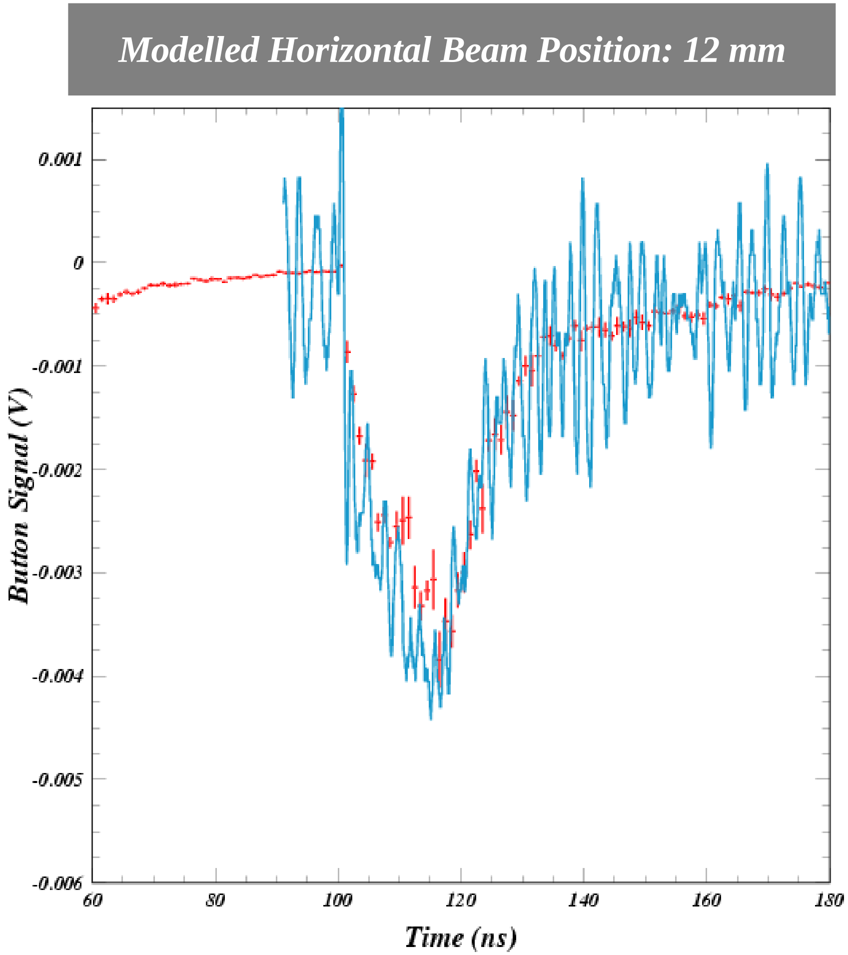
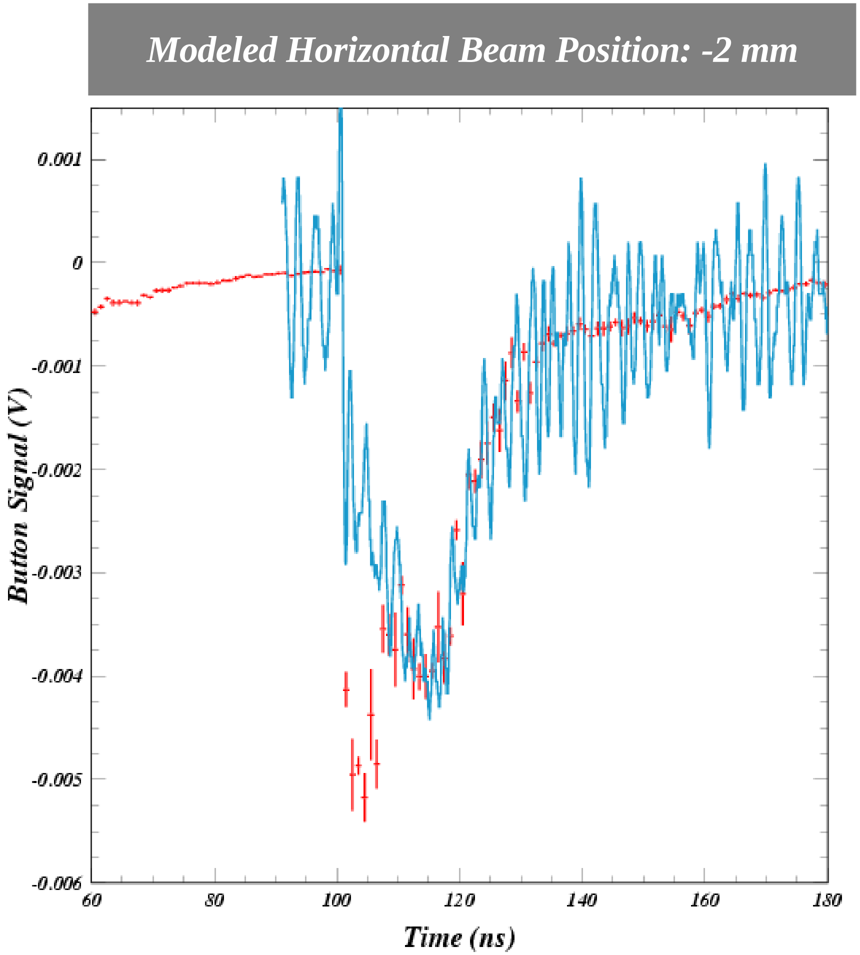
Electron Cloud Meeting
11 May 2011

2.1 GeV Witness Bunch Study

5/9/11: 15E, Carbon, 2.1 GeV, 3 mA/bunch e+ beam
Slides 5,6 of 20 April 2011 talk



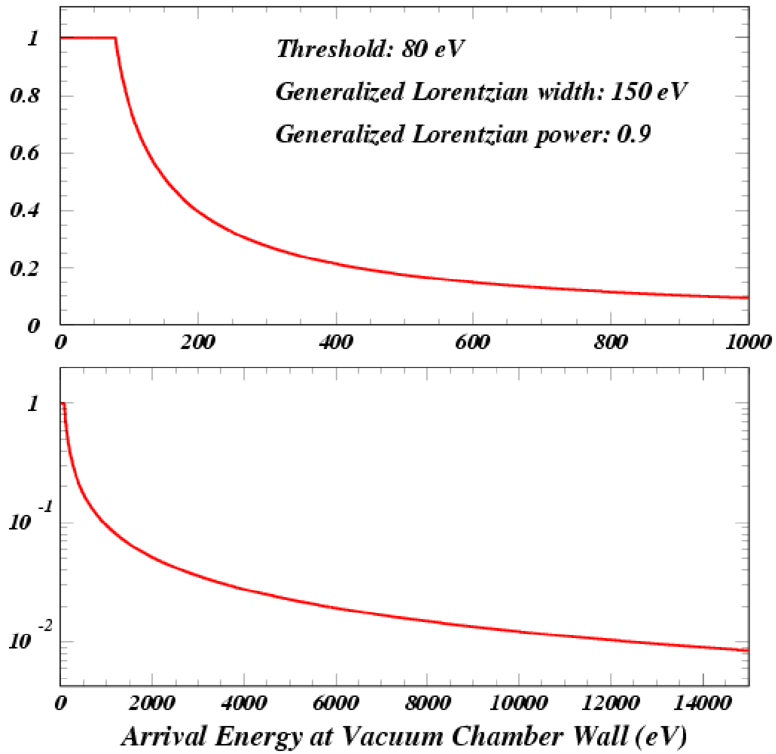


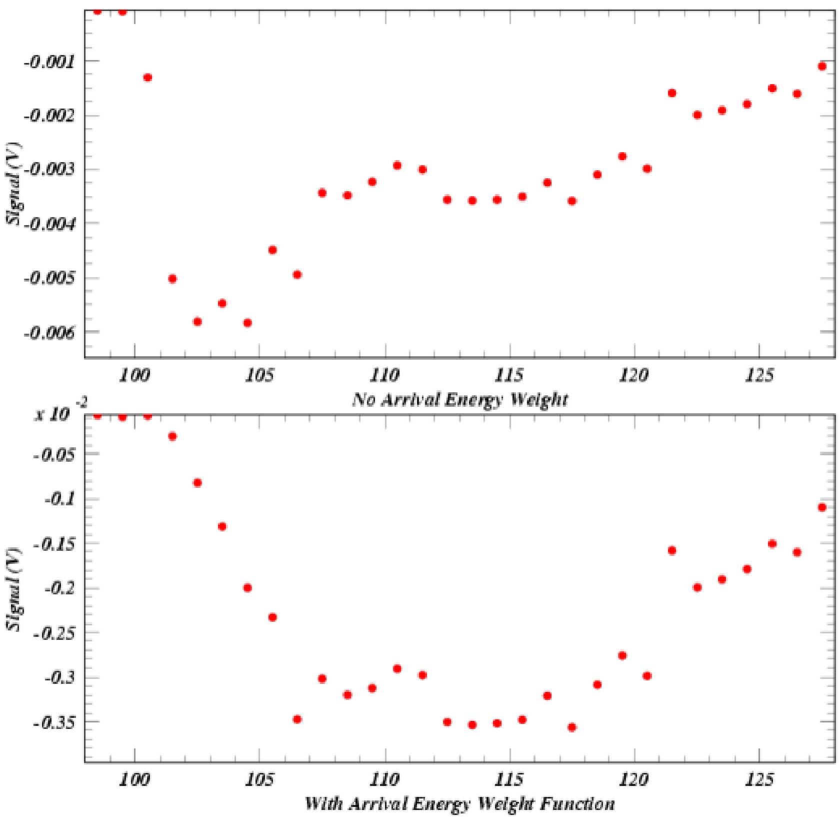
The successful modeling of the witness bunch studies has required the beam to be offset horizontally until now. However, we know the beam is NOT offset. The beam is directly under the central button (9-mm radius). The model exhibits a fast signal from cloud particles accelerated by the bunch. There is no such signal.

The Sikora Conjecture

High energy secondaries off the button escape the 50-V bias field

Suppress the signal from cloud electrons with high incident energy.
Tune the weight function using the SPU signal death certificates and the witness bunch signal shape.





Model the arrival energy dependence as a generalized Lorentzian (3 parameters): $F(E) \sim 1 / (E - E_{pk})^{P} + (\Gamma / 2)^{P}$

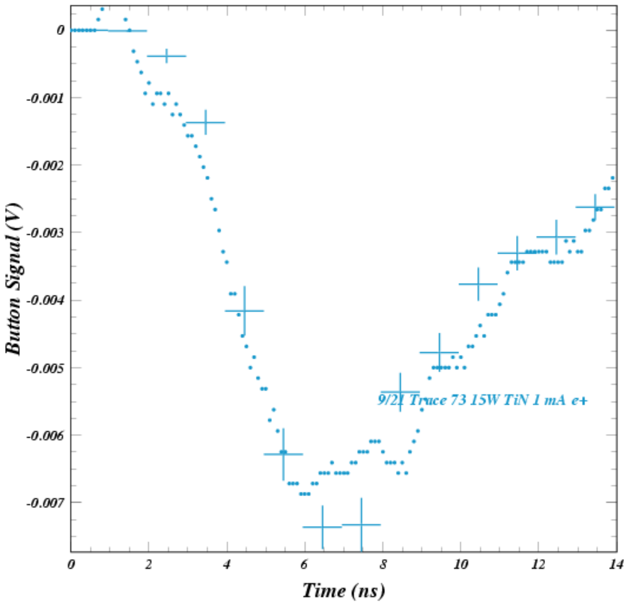
Supporting evidence from the bunch current scans

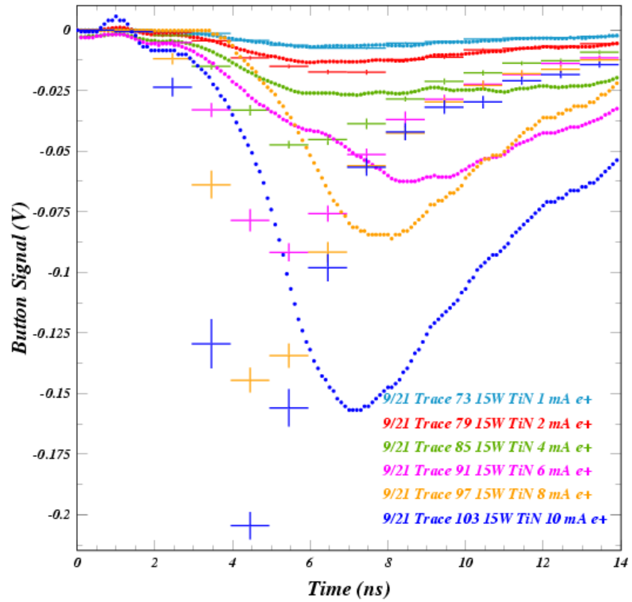
Example: 9/21 15W TiN 5.3 GeV e+ 1-10 mA/bunch

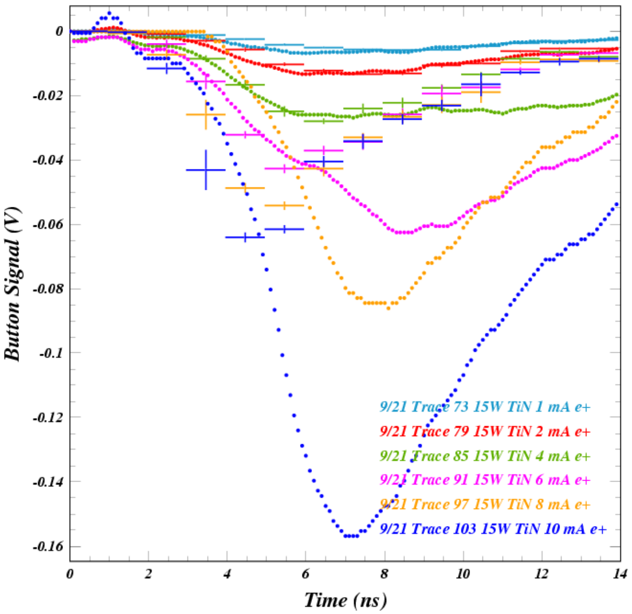
1-mA leading bunch signal
The photoelectron energy distribution determines the risetime.

10-mA leading bunch signal
The risetime is determined by the beam kick.

Suppressing the high arrival energy signal improves the 10-mA signal while preserving the 1-mA signal.







The power-law energy distribution which describes the leading-bunch signal shape for a 1-mA bunch is inconsistent with the observed 10-mA bunch signal!! No energy distribution will work for both. The problem is solved by the same arrival energy weight function which describes the late witness bunch signal shape. The remaining 10-mA signal can be described by a low-energy component which does not contribute to the 1-mA signal.

Summary

- *We have tested an assumption that some secondaries produced on the shielded pickup electrode by high-energy incident electrons escape the 50-volt positive bias.*
- *A signal-suppressing arrival-energy weight function has been installed in ECLOUD, resolving a long-standing problem with the signal shape for late witness bunches.*
- *After tuning the threshold/power-law function on the signal shape of late witness bunches, we find that the same function resolves another long-standing inconsistency in the bunch-current dependence of leading bunch signals.*

Remarks

- *Our knowledge of the secondary emission process should inform our investigation/model-building. High-energy secondaries can be produced either by the re-diffused component or the elastic component. According to the Furman/Pivi PRSTAB article, unprocessed stainless steel has a much higher re-diffused probability than copper (0.7 rather than 0.2). However, in sputtered vacuum chambers, the buttons may or may not be coated.*
- *Can our SEY station provide quantitative information? The Phase 1 report cites the use of a bias voltage of 150 V to capture the secondaries. How do the curves vary as the bias voltage is lowered to 50 V for a stainless steel sample?*

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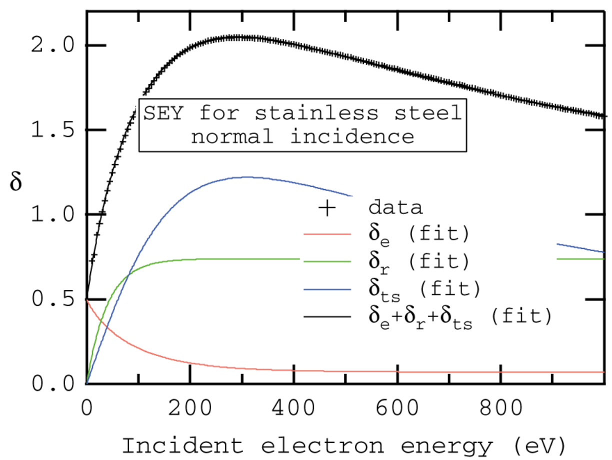
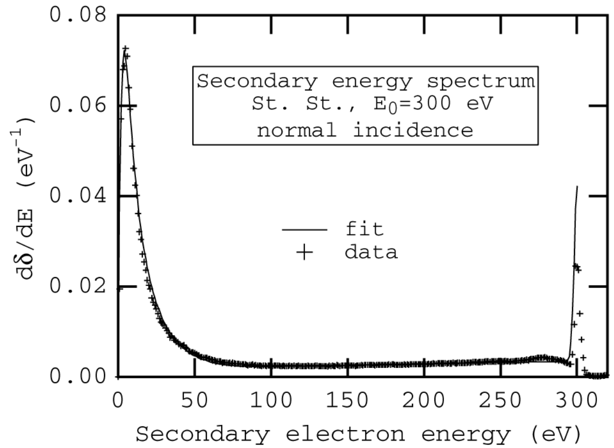
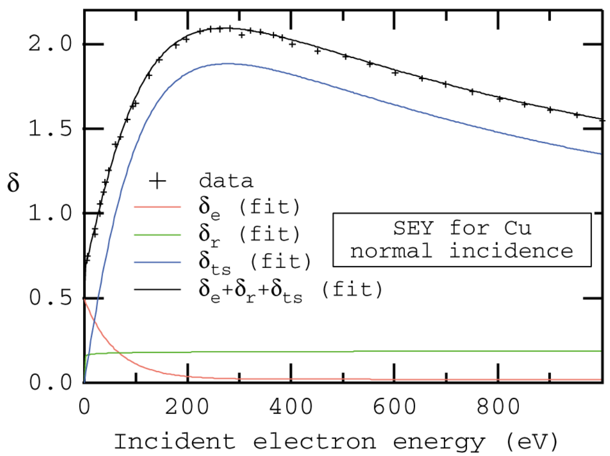
Furman & Pivi PRSTAB Nr 5, 124404 (2002)

Probabilistic Model for The Simulation of Secondary Emission







For 300 eV incident energy the arrival-energy weight function is about 30%, i.e. 70% is lost.

This can be compared to the Furman-Pivi elastic+re-diffused value of approximately (0.07 + 0.74)/2.0 = 40%.

TABLE I. Main parameters of the model.

	Copper	Stainless steel
	Emitted angular spectrum (Sec. IIC1)	
α	1	1
	Backscattered electrons (Sec. IIIB)	
$P_{1,e}(\infty)$	0.02	0.07
$\hat{P}_{1,e}$	0.496	0.5
$\hat{E}_e$ (eV)	0	0
W (eV)	60.86	100
p	1	0.9
σ_e (eV)	2	1.9
e_1	0.26	0.26
e_2	2	2
	Rediffused electrons (Sec. IIIC)	
$P_{1,r}(\infty)$	0.2	0.74
E_r (eV)	0.041	40
r	0.104	1
q	0.5	0.4
r_1	0.26	0.26
r_2	2	2
	True-secondary electrons (Sec. IIID)	
$\hat{\delta}_{ts}$	1.8848	1.22
$\hat{E}_{ts}$ (eV)	276.8	310
s	1.54	1.813
t_1	0.66	0.66
t_2	0.8	0.8
t_3	0.7	0.7
t_4	1	1
	Total SEY[a]	
$\hat{E}_t$ (eV)	271	292
$\hat{\delta}_t$	2.1	2.05

[a]Note that $\hat{E}_t \simeq \hat{E}_{ts}$ and $\hat{\delta}_t \simeq \hat{\delta}_{ts} + P_{1,e}(\infty) + P_{1,r}(\infty)$ provided that $\hat{E}_{ts} \gg \hat{E}_e, E_r$.

The re-diffused component for stainless steel is remarkably high relative to copper/aluminum (0.74 vs 0.20). The threshold is relatively high energy (40 eV vs 0.041 eV), but less than 50 V. The elastic yield is similarly higher at high energy (0.07 vs 0.02).

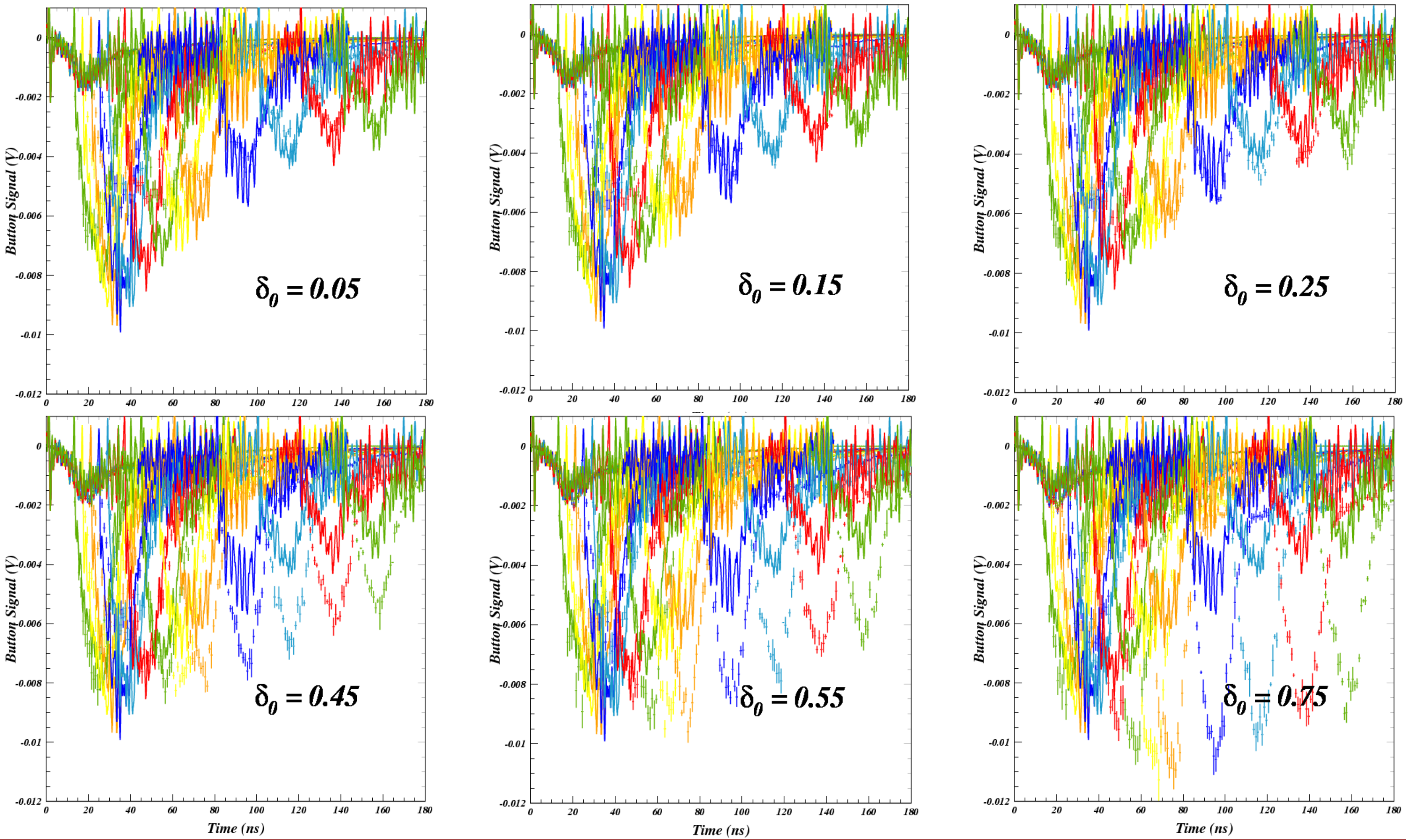
Next Steps

- ***Overhaul and generalize the photoelectron model in ECLOUD.***
  - ***Provide for a mixture of four electron distribution functions: Gaussian, the present power law, a generalized (e.g. asymmetric) Lorentzian-like power law, and Gerry's few-parameter hybrid.***
  - ***Provide for different energy distributions for photoelectrons produced by direct and reflected photons.***
- ***Upgrade the SPU front-end to raise the bias voltage to 250 V (capacitor specs).***
  - ***Button 4 at 15W was upgraded yesterday. The first bias voltage scan at 5.3 GeV was done parasitically this morning (CHESS condx, e+, e- 7 mA/bunch, 5-bunch trains). The effect on the SPU signals was at the 10% level for bias voltages between 50 and 250 V. NB: Only "late witness bunches" are too late (>200 ns).***
  - ***In order to explore the sensitivity to the bias voltage, custom single-bunch and two-bunch current scans are needed. They can be done during Tuesday machine studies with moderate time requests of about an hour.***
- ***Repeat the standard sets of SPU measurements with various bias voltages. These have been scheduled for the June CesrTA run.***

2.1 GeV Witness Bunch Study

5/9/11: 15E, Carbon, 2.1 GeV, 3 mA/bunch e+ beam, 14-ns spacing

We DO have such a study for carbon at 15E, but with 4-ns spacing



Full scan of elastic yield values for the 9 May 2010 carbon data.
The data quality reduces the discriminating power for the elastic yield. Values greater than 0.25 are excluded.