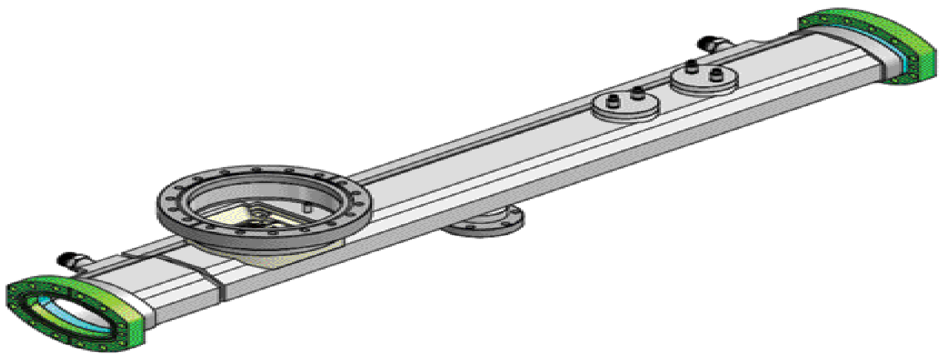
Cornell University
Laboratory for Elementary-Particle Physics

Physics Scope and Work Plan for the Shielded-Pickup Measurements

-- Synchrotron Radiation Photon Distributions --

-- Photoelectron Production Parameters --

-- Secondary Yield Parameters --

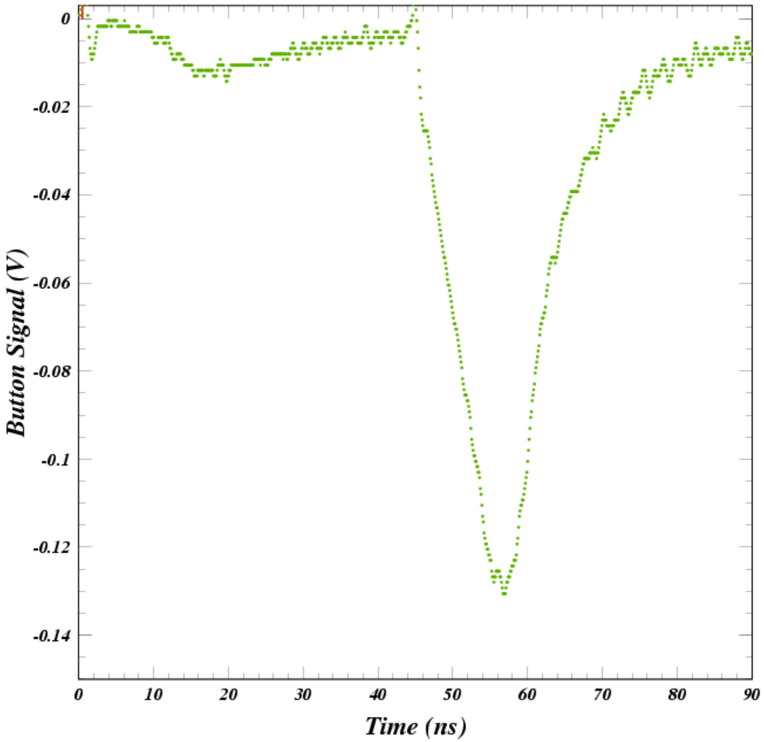


Jim Crittenden
Cornell Laboratory for Accelerator-Based Sciences and Education
CesrTA Electron Cloud Simulation Coordination Meeting
3 March 2011

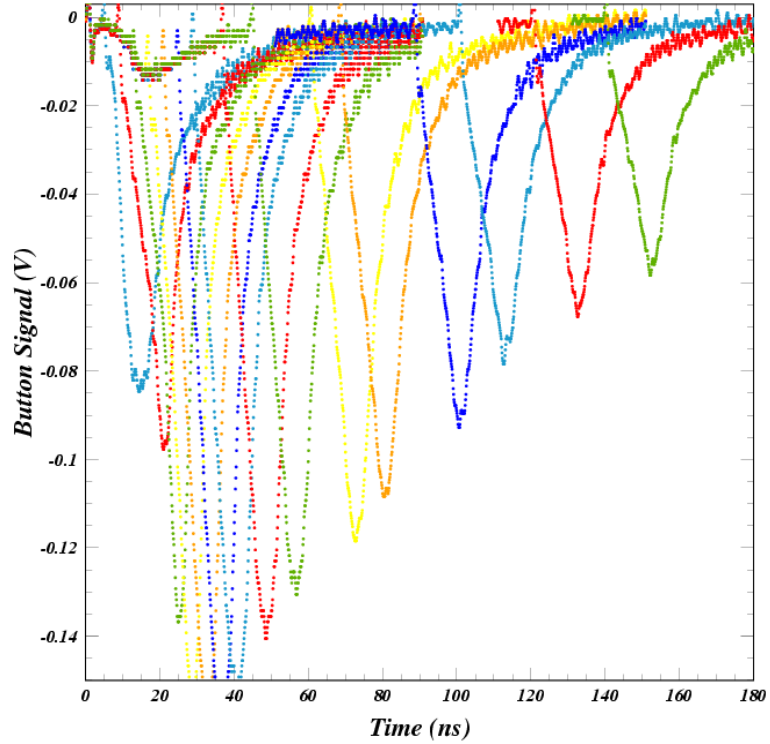
Example of a Witness Bunch Study: 9 May 2011

15W, Al v.c., 2.1 GeV, 3 mA/bunch e+ beam, 4-ns spacing increments

Shielded pickup scope trace for two bunches 44 ns apart



Superposition of 15 such traces illustrating the sensitivity to cloud lifetime

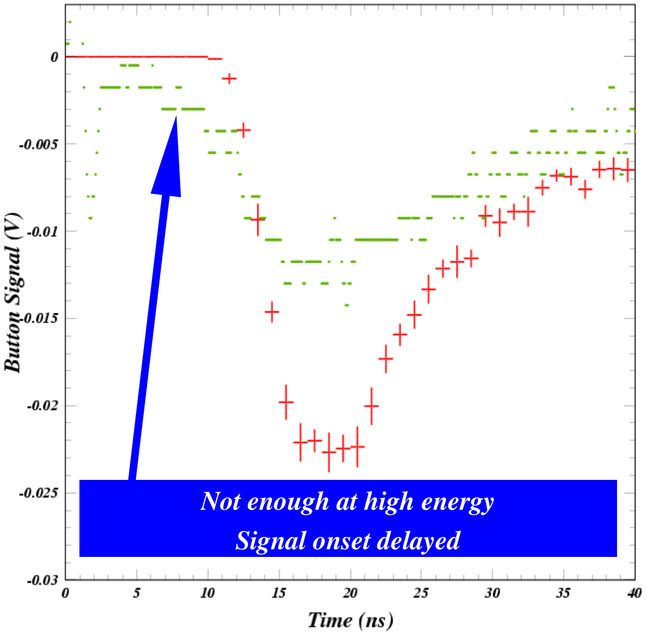


The single bunch signal arises from photoelectrons produced on the bottom of the vacuum chamber. Its shape is thus closely related to the photoelectron kinetic energy distribution modulo the beam kick.

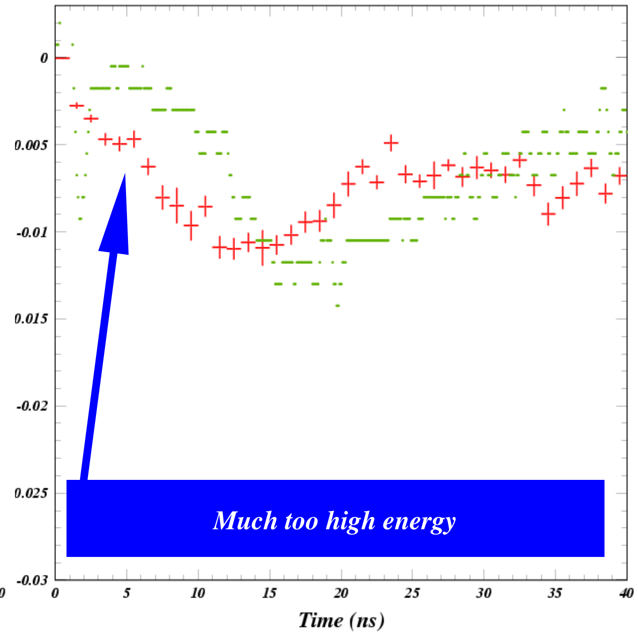
The witness bunch signal includes the single-bunch signal as well as the that produced by cloud particles accelerated into the shielded pickup by the kick from the witness bunch.

Sensitivity of the single bunch signal to the p.e. energy distribution
2.1 GeV, e+ beam, $E_{critical}$ = 0.23 keV

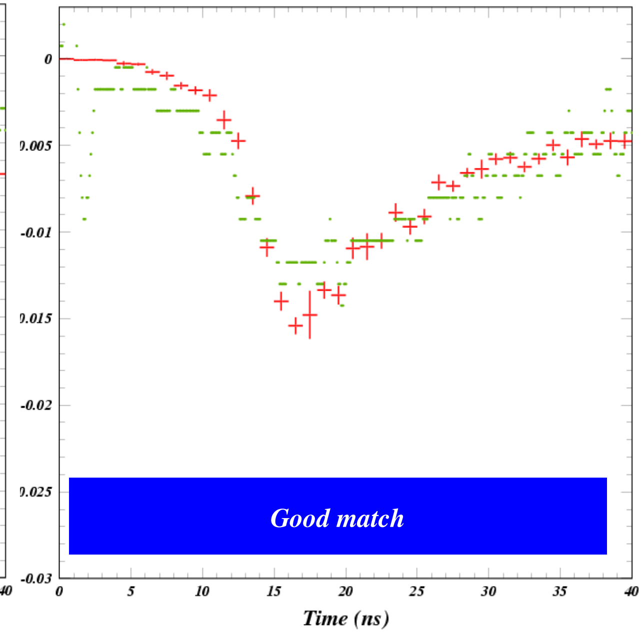
Original ECLOUD
Gaussian with Epk, rms = 5 eV 5 eV



Power-law found to match 5.3 GeV
$E^{P1} / (1 + E/E_0)^{P2}$
E_{peak}, P1,P2 = 4 eV 3.6 5.2



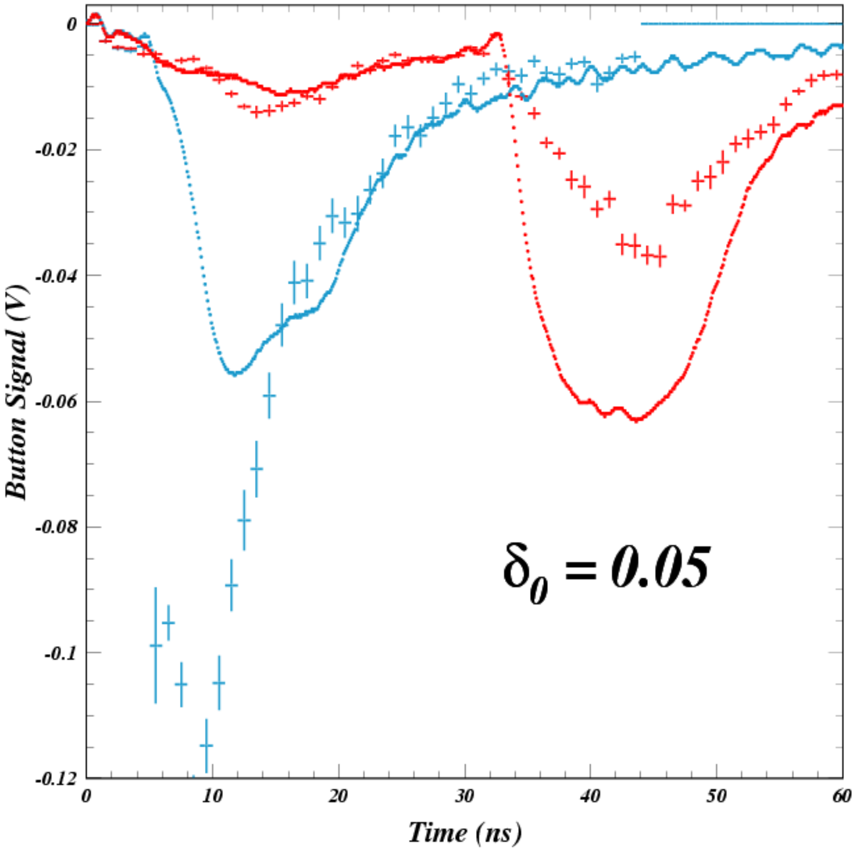
Lorentzian with E_{peak}, width = 5 eV, 7 eV



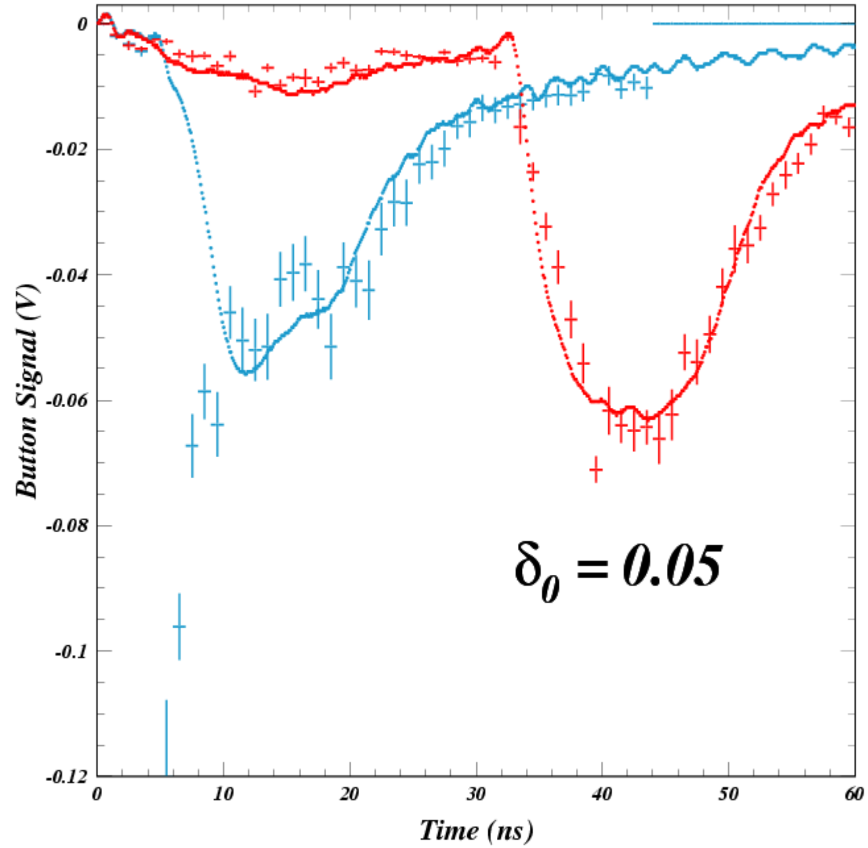
Examples of photoelectron energy distributions modeled in ECLOUD.

Additional sensitivity of the witness bunch studies to photoelectron azimuthal distributions
-- First experimental support for the SYNRAD3D model --

Uniform



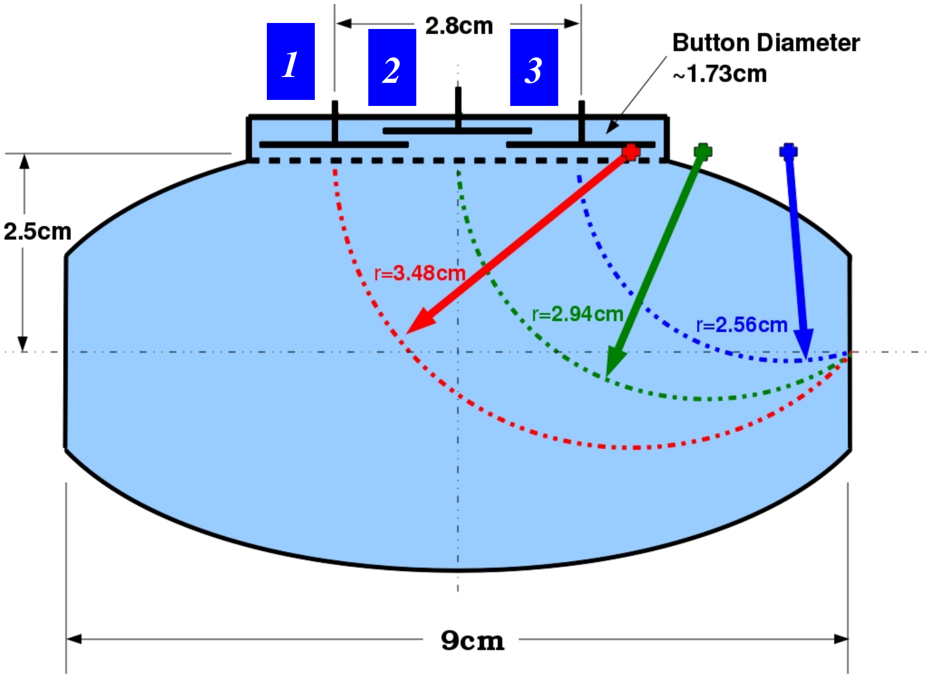
SYNRAD3D

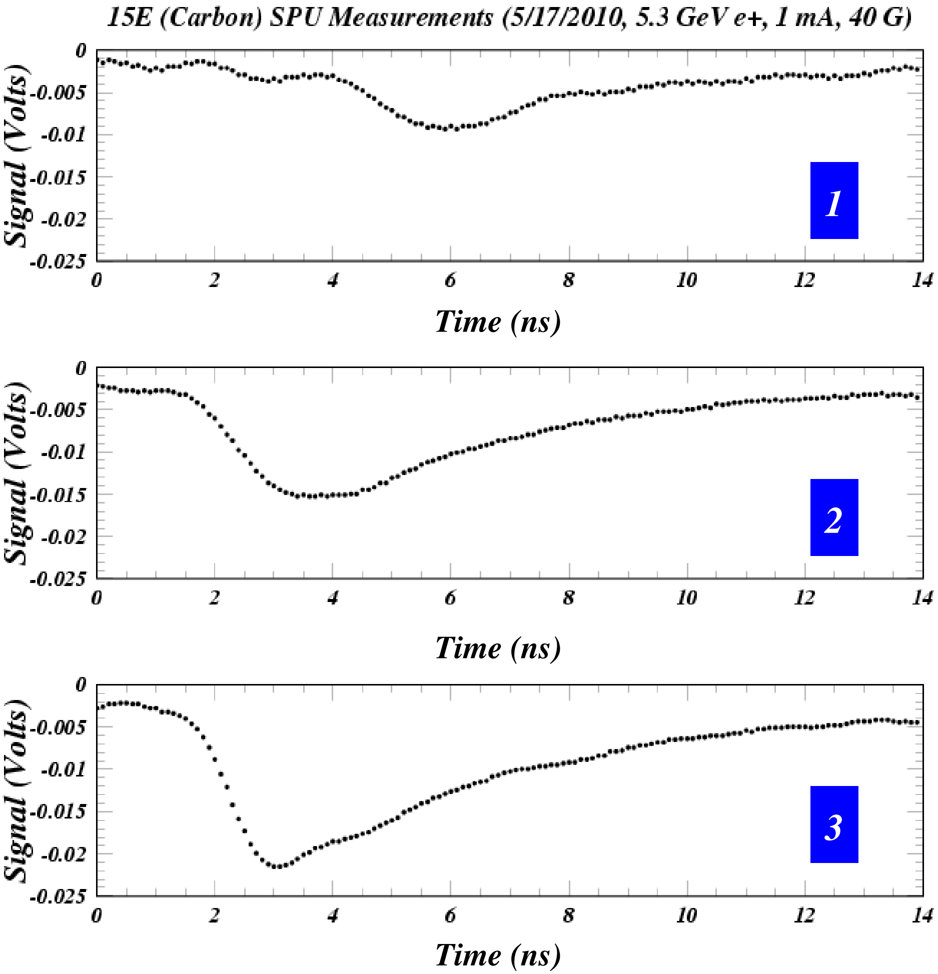


The SYNRAD3D azimuthal distribution is a remarkable improvement, both for the shape of the single-bunch signal and for the shapes and relative sizes of the witness bunches at 4 and 32 ns.

This improvement arises primarily from the SYNRAD3D prediction of substantial p.e. production on the 'wrong side' of the vacuum chamber.

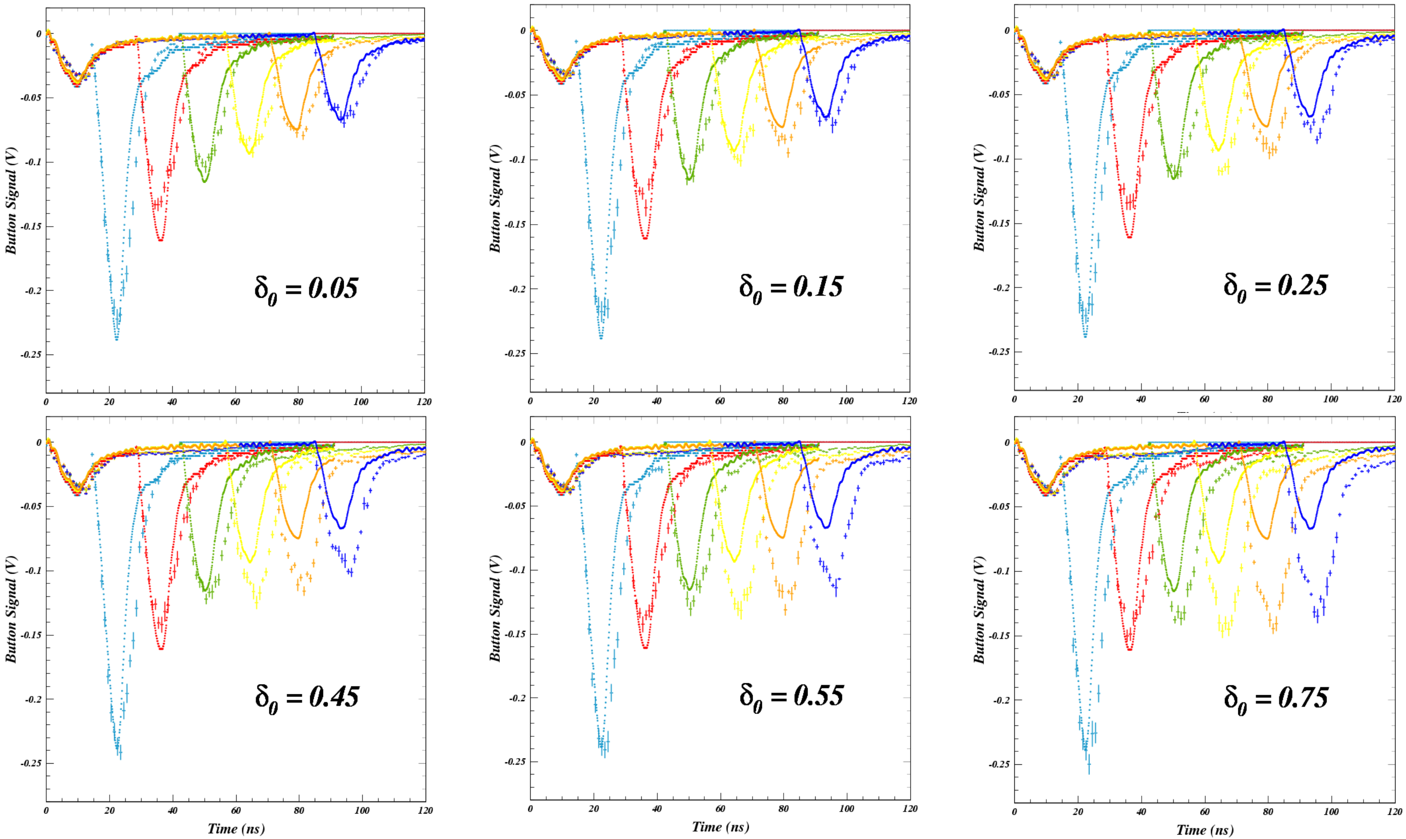
Spectrum analysis of the direct s.r. photons using the solenoidal magnetic field
Example: 5.3 GeV 1 mA/bunch e+ beam, 40 Gauss





The risetimes of the signals from the three buttons clearly show the differing acceptance at high photoelectron energy. These measurements may also provide information on the production angular distribution.

ECLOUD sensitivity to secondary electron yield parameters
3/27/11: 15E, TiN, 5.3 GeV, 5 mA/bunch e+ beam, 14-ns spacing



Correlation studies with ECLOUD have shown the secondary yield parameters to be decoupled. The first bunch signal arises primarily from photoelectrons. The early witness bunch signal amplitudes depend primarily on the true and rediffused SEY components. The decrease in signal amplitude for late witness bunches is closely related to the elastic yield parameter δ_0.

This example shows a preferred value for the TiN coating of δ_0=0.05. A similar value was found for amorphous carbon coatings, while the value for bare Al was 0.75.

Witness Bunch Study Data Sets 2011

Date	Species	(GeV)	Bunch Current (mA)	15E/W	Vacuum Chamber	Spacing	Data Sets	ECLOUD
03/27/11	Positrons	5.3	5	W	Carbon (1)	14-84	11-74	19271-19306
				E	TiN		11-74	18404-18439
03/27/11	Electrons	5.3	5	W	Carbon (1)	14-70	110-146	
				E	TiN		110-146	
05/09/11	Positrons	2.1	3	W	Al	4-140	43-85	20205-20294
				E	Carbon (2)		73-199	20295-20384
05/09/11	Electrons	2.1	3	W	Al	4-20	91-103	
				E	Carbon (2)		217-253	
05/17/11	Positrons	5.3	3	W	Al	4-100	70-109	17781-17858
				E	Carbon (2)		139-211	19793-19870
05/17/11	Electrons	5.3	3	W	Al	4-100	166-199	
				E	Carbon (2)		325-391	
05/19/11	Electrons	2.1	3	W	Al	4-120	91-139	
				E	Carbon (2)		181-277	
12/24/11	Positrons	5.3	3,5	W	TiN	14-84	436-491	
				E	Carbon (2)		436-491	
12/24/11	Electrons	5.3	3,5	W	TiN	14-84	496-551	
				E	Carbon (2)		496-551	

Many systematic studies completed.

Photoelectron energy distributions determined for s.r. critical energies of 0.23, 0.34, 1.6, 2.4, 3.7, 5.6 keV.

Production analyses can begin.

Work Plan

I. *ECLOUD analysis of the existing data sets (nonzero probability of a summer student)*

A. *Continue studies of systematics and parameter correlations*

B. *Witness bunch studies*

i) *Compile SEY parameter values for amorphous carbon, TiN and bare aluminum.*

ii) *Test SYNRAD3D calculations of photon scattering (contingent on CESR v.c. modeling) .*

iii) *Compile photoelectron energy distributions for scattered photons.*

C. *Solenoid field scans*

i) *Compile photoelectron energy distributions for direct photons. Since the photon energy distribution is well known it may be possible to derive energy-dependent quantum efficiencies.*

ii) *Test sensitivity to the photoelectron production angular distribution.*

II. *Measurements for the upcoming data-taking periods in April and June*

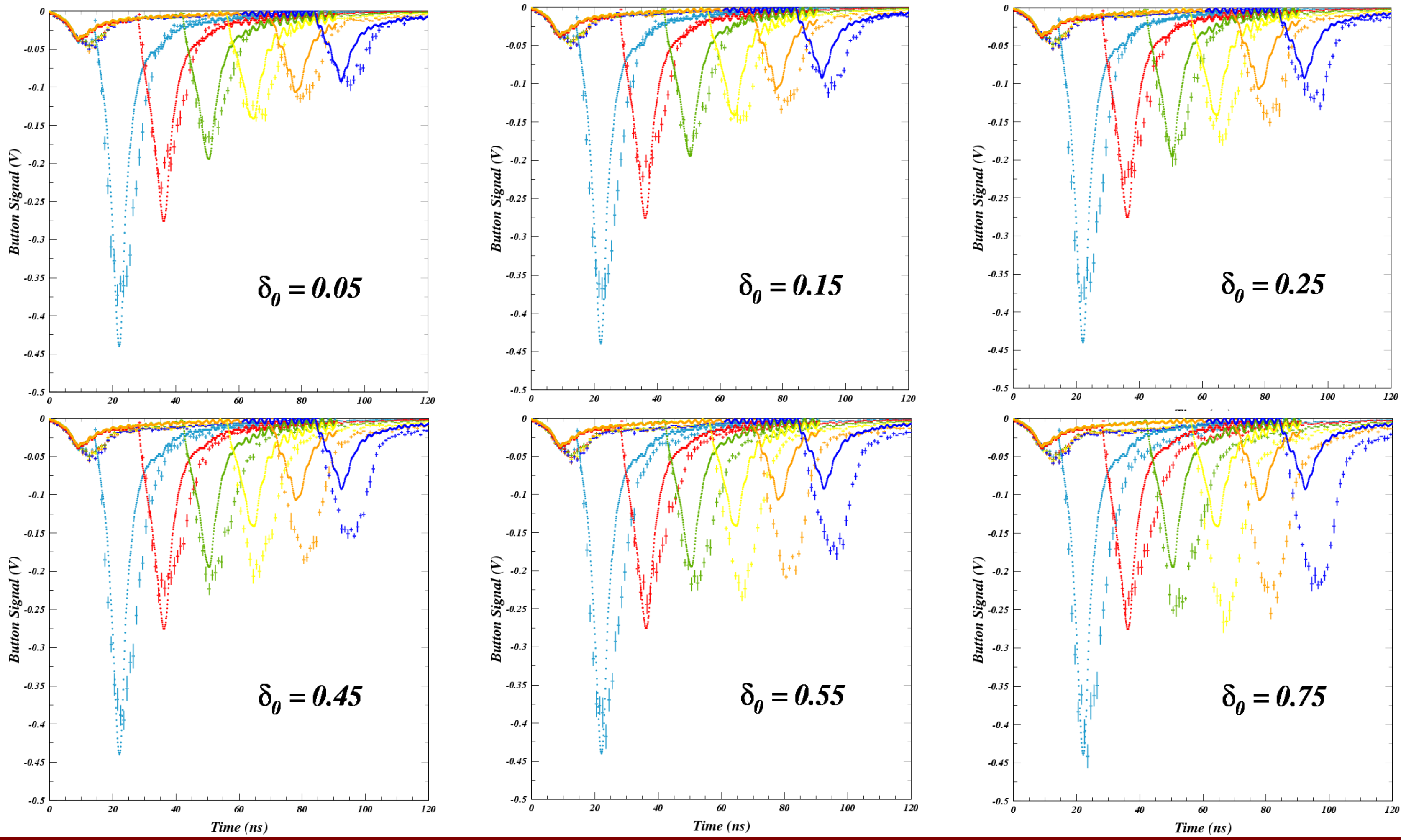
A. *Repeat the above studies for the diamond-like carbon coated chamber at 15E*

B. *Measure horizontal beam-position dependence of the SPU signals*

Electron cloud meeting 24 Nov 2011: Parameter correlation study

ECLOUD cloud lifetime sensitivity to elastic yield δ_0

Data set 3/27/2011: 5.3 GeV 5 mA/bunch e+ beam for 15W carbon-coated v.c.

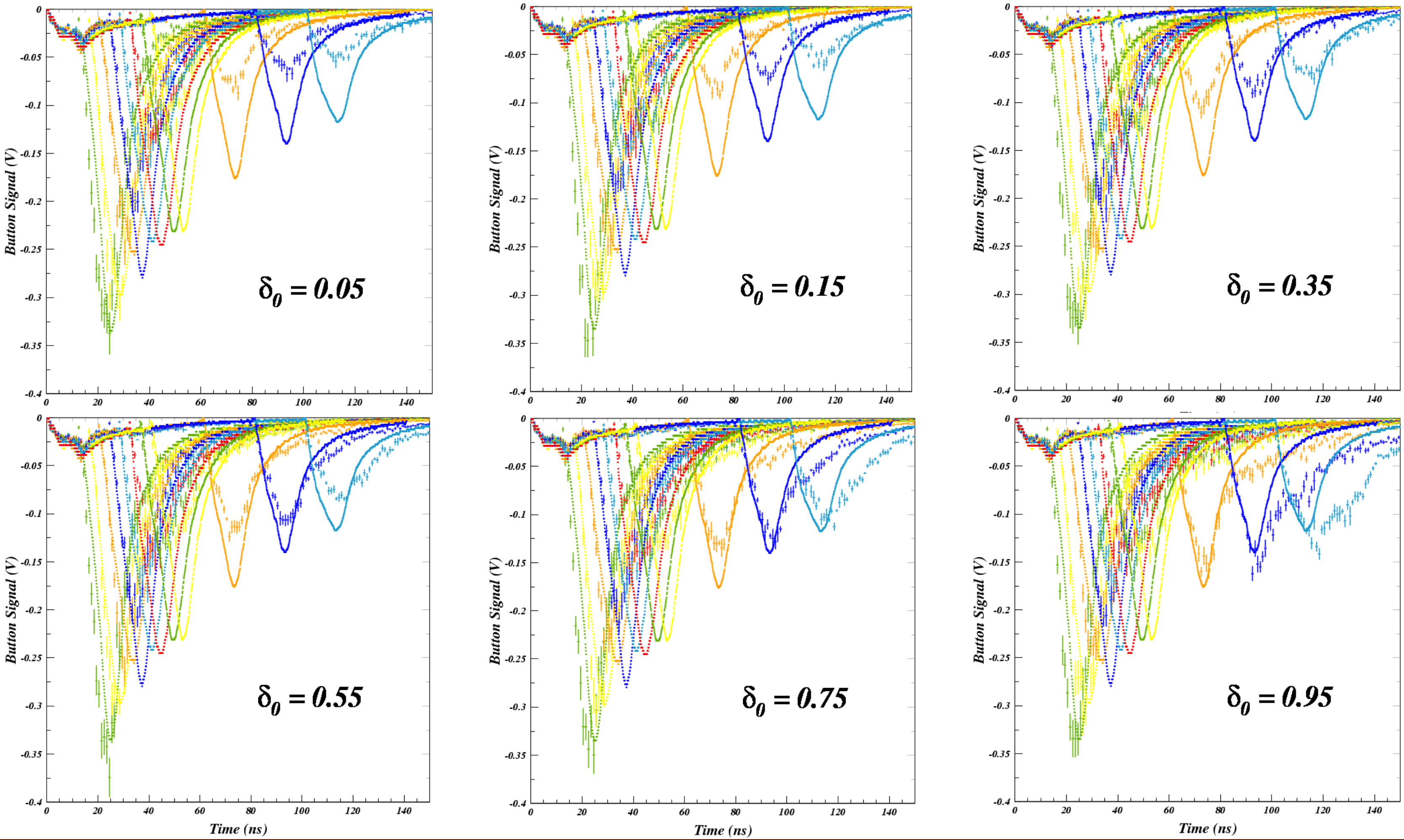


Baseline parameters: 0.9 γ/m/s, q.e. 5%, reflectivity 20%, $\delta_{ts} = 0.7$, $E_{pk} = 400$ eV, $\delta_{red} = 0.1$.

SPU signal scaled by factor 1.7. Elastic yield parameter $\delta_0 = 0.05$ is the best match.

ECLOUD cloud lifetime sensitivity to elastic yield δ_0

Data set 5/17/2011: 5.3 GeV 3 mA/bunch e+ beam for 15W, Al v.c.



Baseline parameters: 0.9 γ/m/s, q.e. 10%, reflectivity 20%, δ_{ts} = 0.9, E_{pk} = 400 eV, δ_{red} = 0.1.

SPU signal scaled by factor 1.1. Elastic yield parameter δ_0 = 0.75 is the best match.