Cornell University
Laboratory for Elementary-Particle Physics

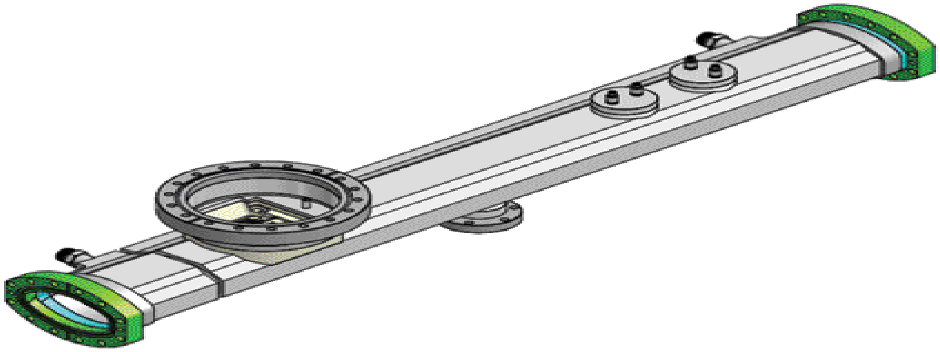
Physics Scope and Work Plan for the Shielded-Pickup Measurements

-- Synchrotron Radiation Photon Distributions --

-- Photoelectron Production Parameters --

-- Secondary Yield Parameters --

--- 7 March: Added 3 slides for vacuum chamber comparisons under same beam conditions ---



Jim Crittenden

Cornell Laboratory for Accelerator-Based Sciences and Education

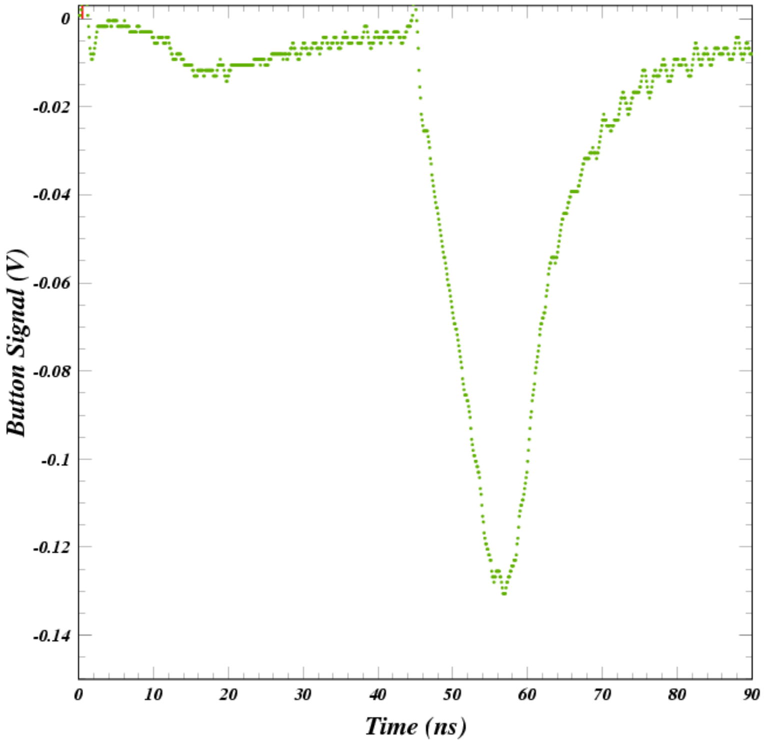
CesrTA Electron Cloud Simulation Coordination Meeting

3 March 2011

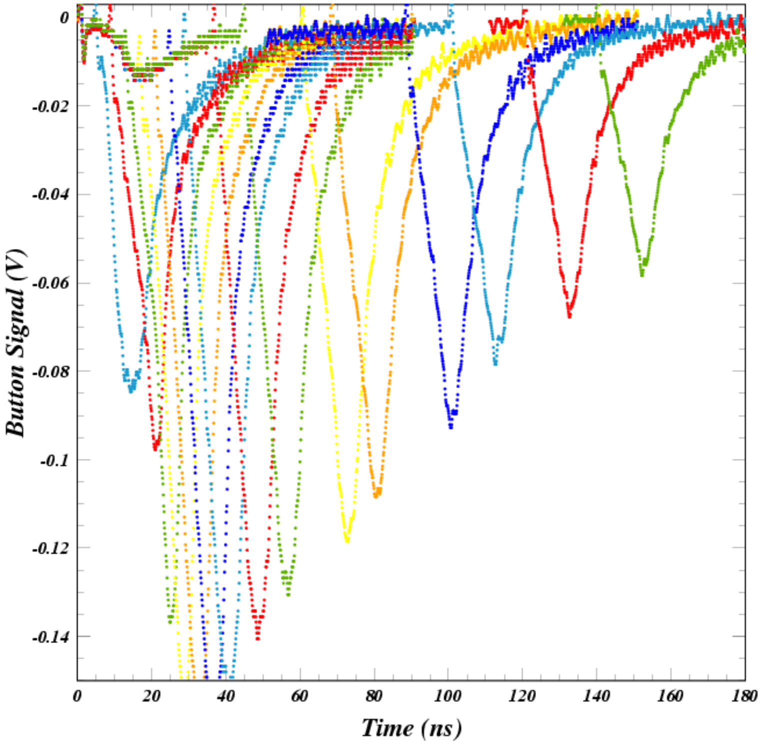
Example of a Witness Bunch Study: 9 May 2010

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.

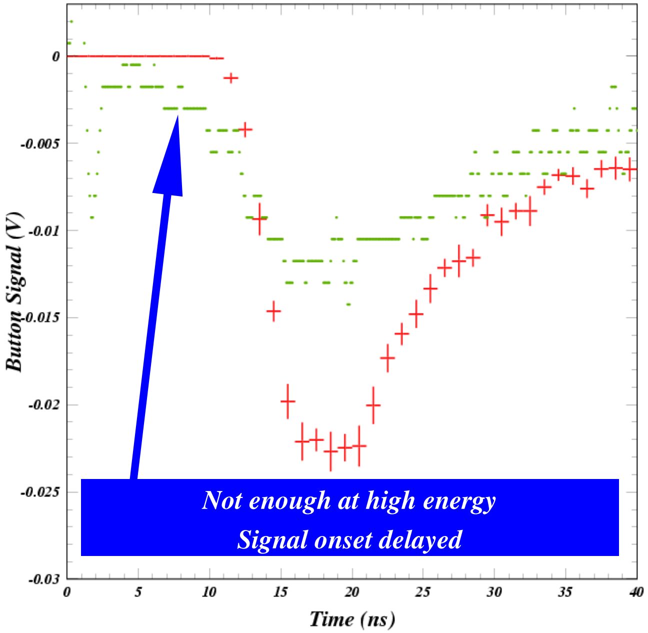
The witness bunch signal includes the single-bunch signal as well as the that produced by cloud particles accelerated into the shielded pickup by the kick from the witness bunch.

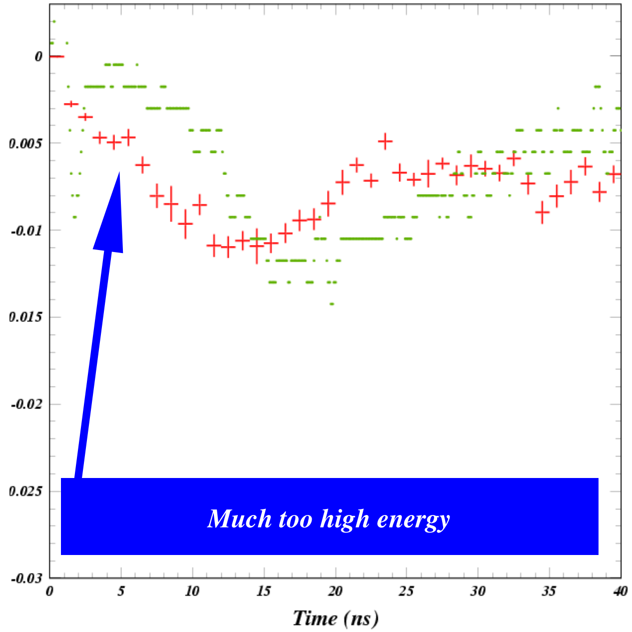
Sensitivity of the single bunch signal to the p.e. energy distribution
2.1 GeV, e+ beam, $E_{critical} = 0.23$ keV

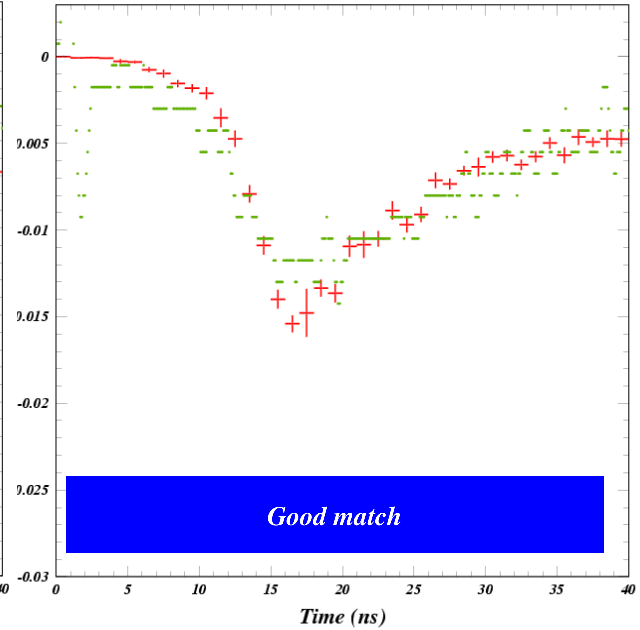
Original ECLOUD
Gaussian with Epk, rms = 5 eV 5 eV

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

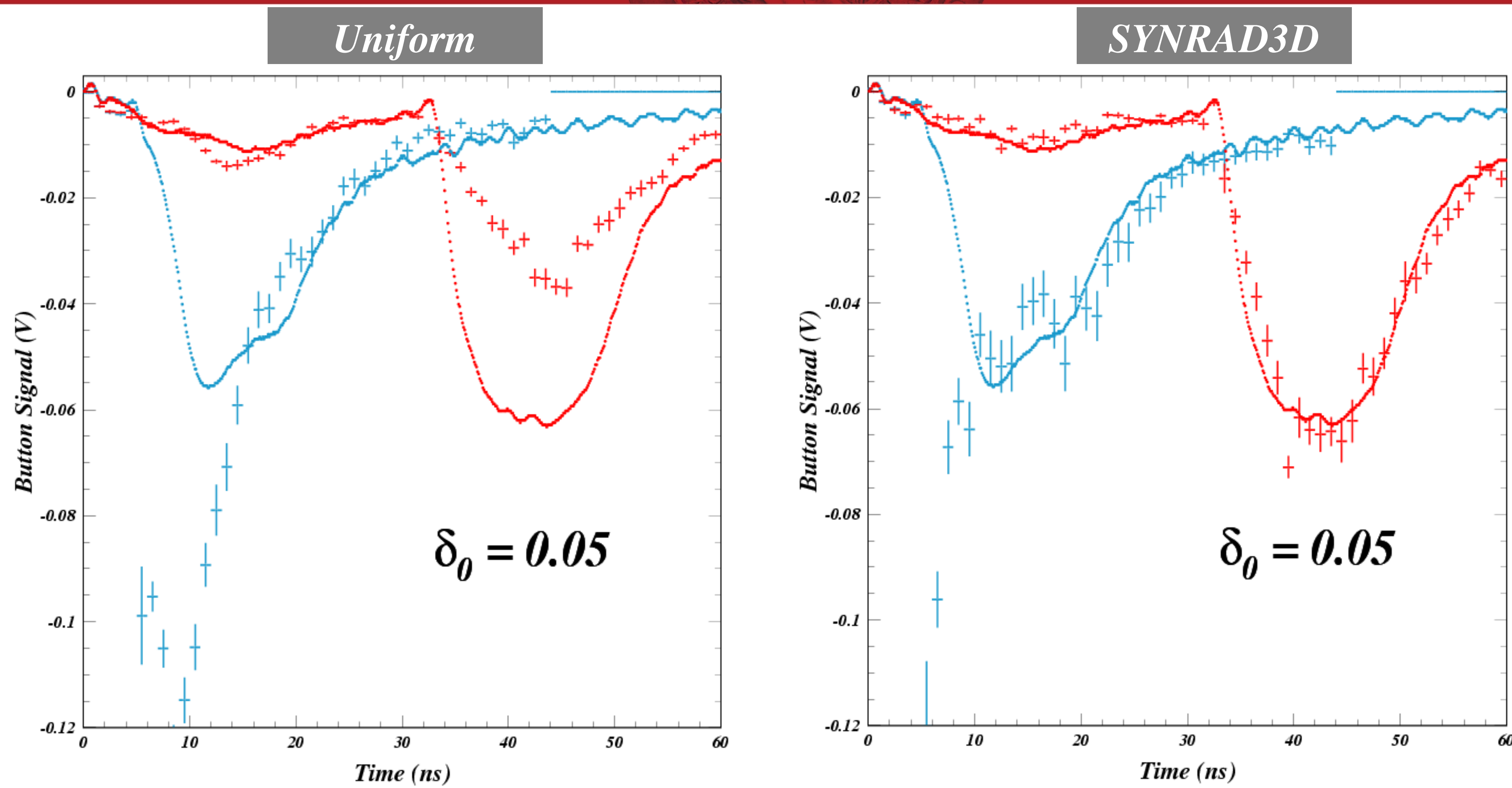






Examples of photoelectron energy distributions modeled in ECLOUD.

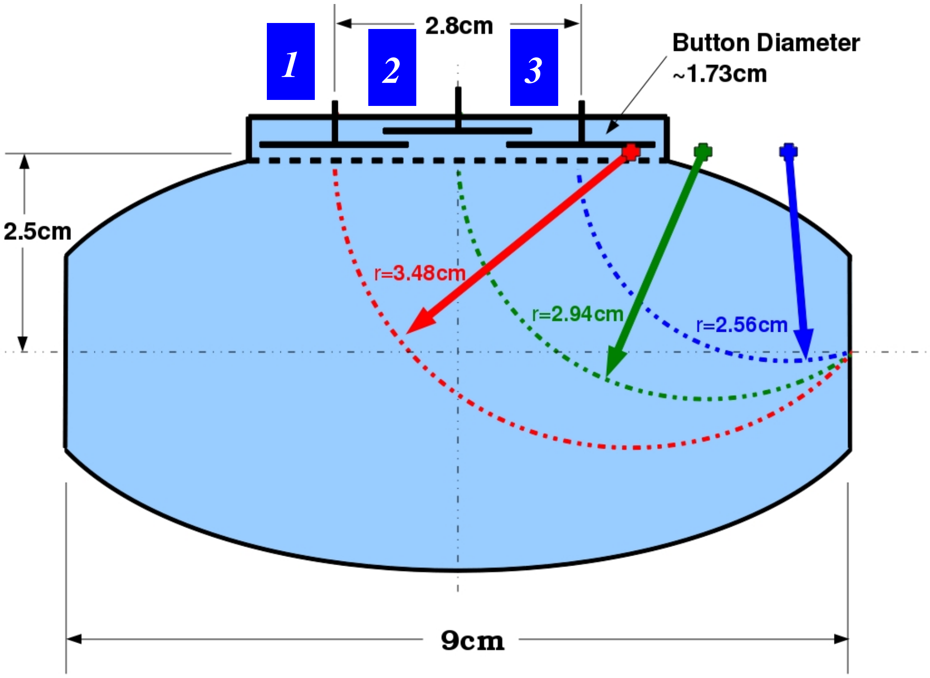
Additional sensitivity of the witness bunch studies to photoelectron azimuthal distributions
-- First experimental support for the SYNRAD3D model --

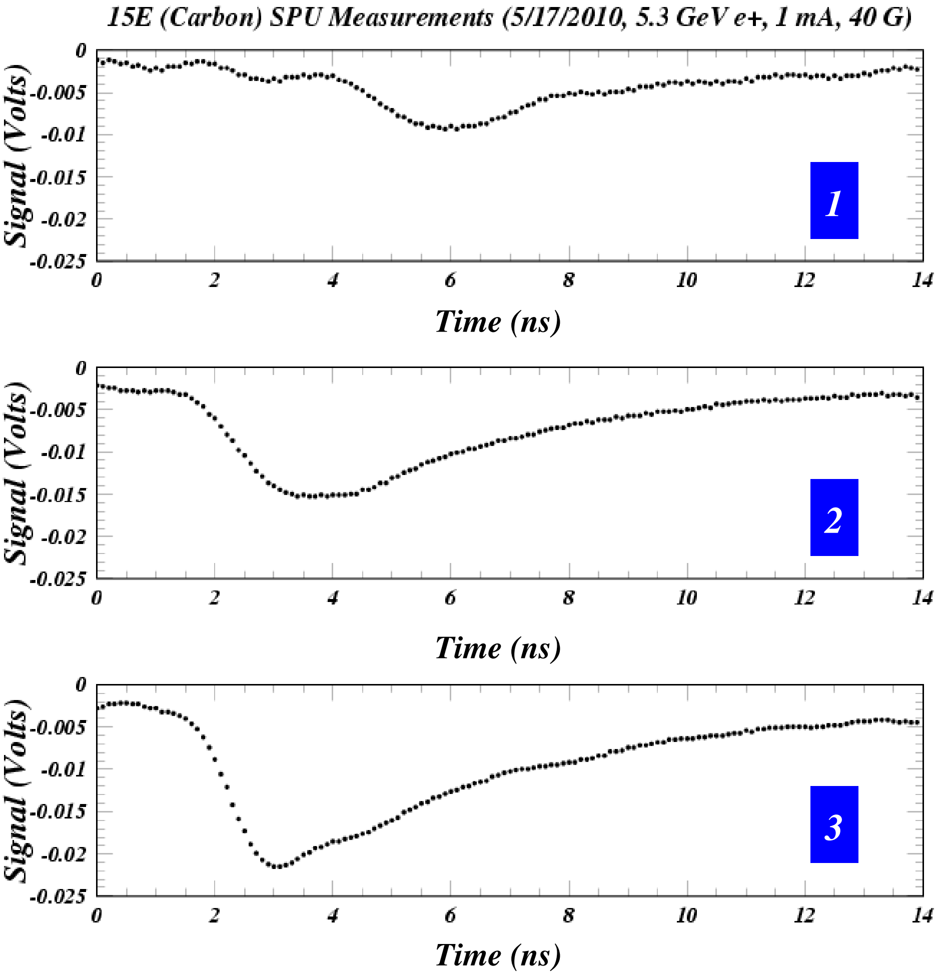


The SYNRAD3D azimuthal distribution is a remarkable improvement, both for the shape of the single-bunch signal and for the shapes and relative sizes of the witness bunches at 4 and 32 ns.

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

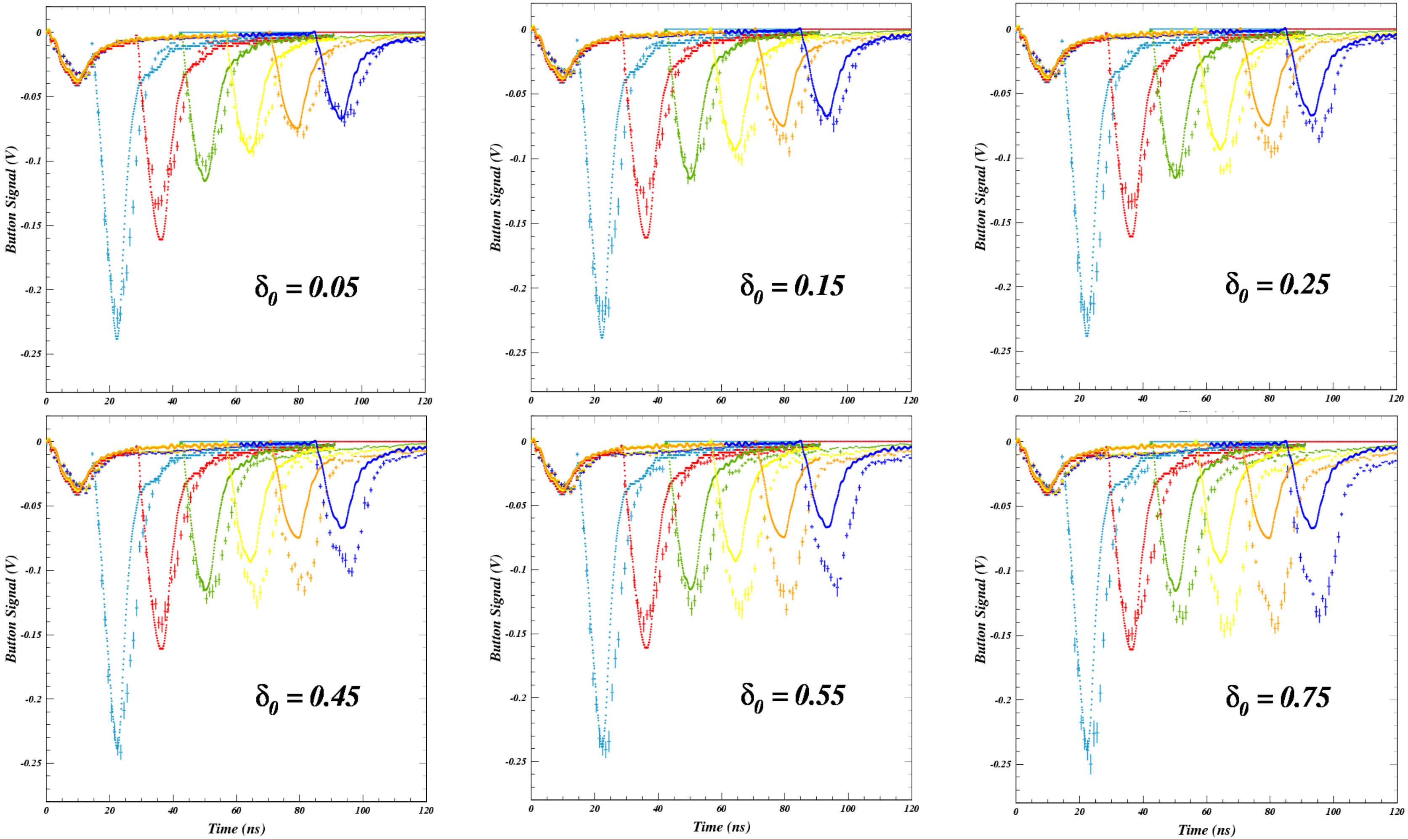
Spectrum analysis of the direct s.r. photons using the solenoidal magnetic field
Example: 5.3 GeV 1 mA/bunch e+ beam, 40 Gauss





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
3/27/10: 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 2010

Date	Species	(GeV)	Bunch Current (mA)	15E/W	Vacuum Chamber	Spacing	Data Sets	ECLOUD
03/27/10	Positrons	5.3	5	W	Carbon (1)	14-84	11-74	19271-19306
				E	TiN		11-74	18404-18439
03/27/10	Electrons	5.3	5	W	Carbon (1)	14-70	110-146	
				E	TiN		110-146	
05/09/10	Positrons	2.1	3	W	Al	4-140	43-85	
				E	Carbon (2)		73-199	
05/09/10	Electrons	2.1	3	W	Al	4-20	91-103	
				E	Carbon (2)		217-253	
05/17/10	Positrons	5.3	3	W	Al	4-100	70-109	17781-17858
				E	Carbon (2)		139-211	19793-19870
05/17/10	Electrons	5.3	3	W	Al	4-100	166-199	
				E	Carbon (2)		325-391	
05/19/10	Electrons	2.1	3	W	Al	4-120	91-139	
				E	Carbon (2)		181-277	
12/24/10	Positrons	5.3	3,5	W	TiN	14-84	436-491	
				E	Carbon (2)		436-491	
12/24/10	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***

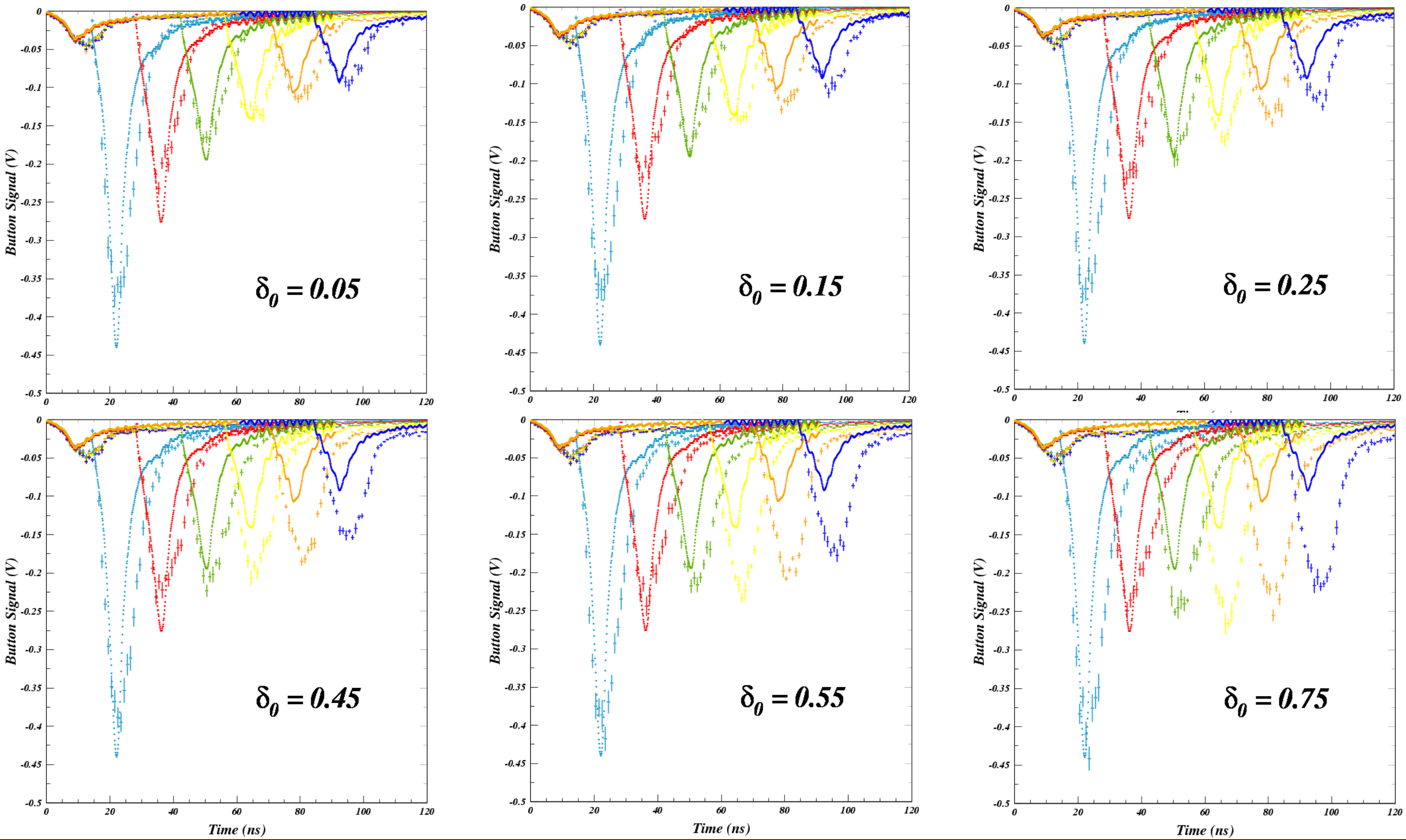
   A. ***Repeat the above studies for the diamond-like carbon coated chamber at 15E***

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

Electron cloud meeting 24 Nov 2010: Parameter correlation study

ECLOUD cloud lifetime sensitivity to elastic yield δ_0

Data set 3/27/2010: 5.3 GeV 5 mA/bunch e+ beam for 15W carbon-coated v.c.

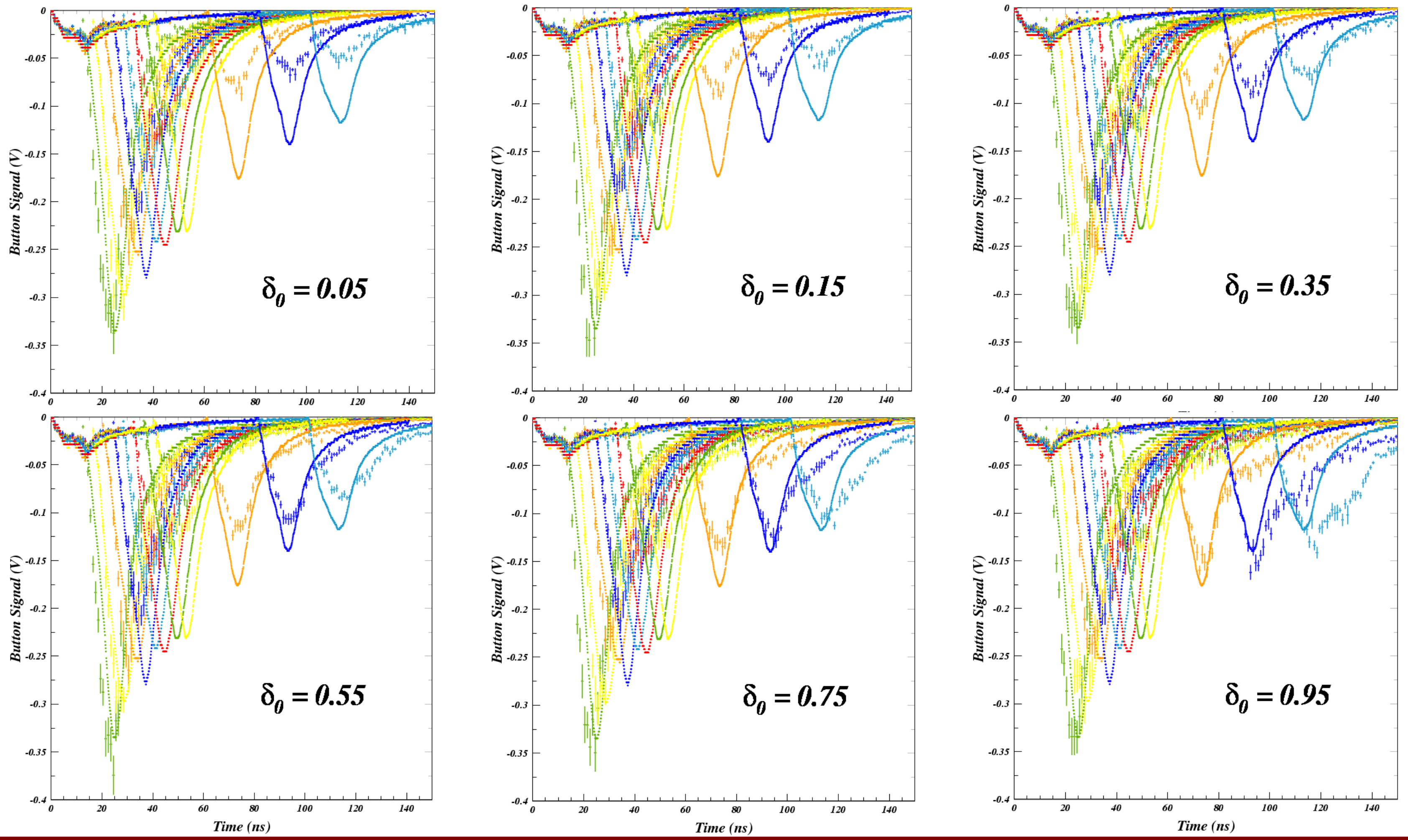


Baseline parameters: 0.9 γ/m/s, q.e. 5%, reflectivity 20%, δ_{ts} = 0.7, E_{pk} = 400 eV, δ_{red} = 0.1.

SPU signal scaled by factor 1.7. Elastic yield parameter δ_0 = 0.05 is the best match.

ECLOUD cloud lifetime sensitivity to elastic yield δ_0

Data set 5/17/2010: 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.

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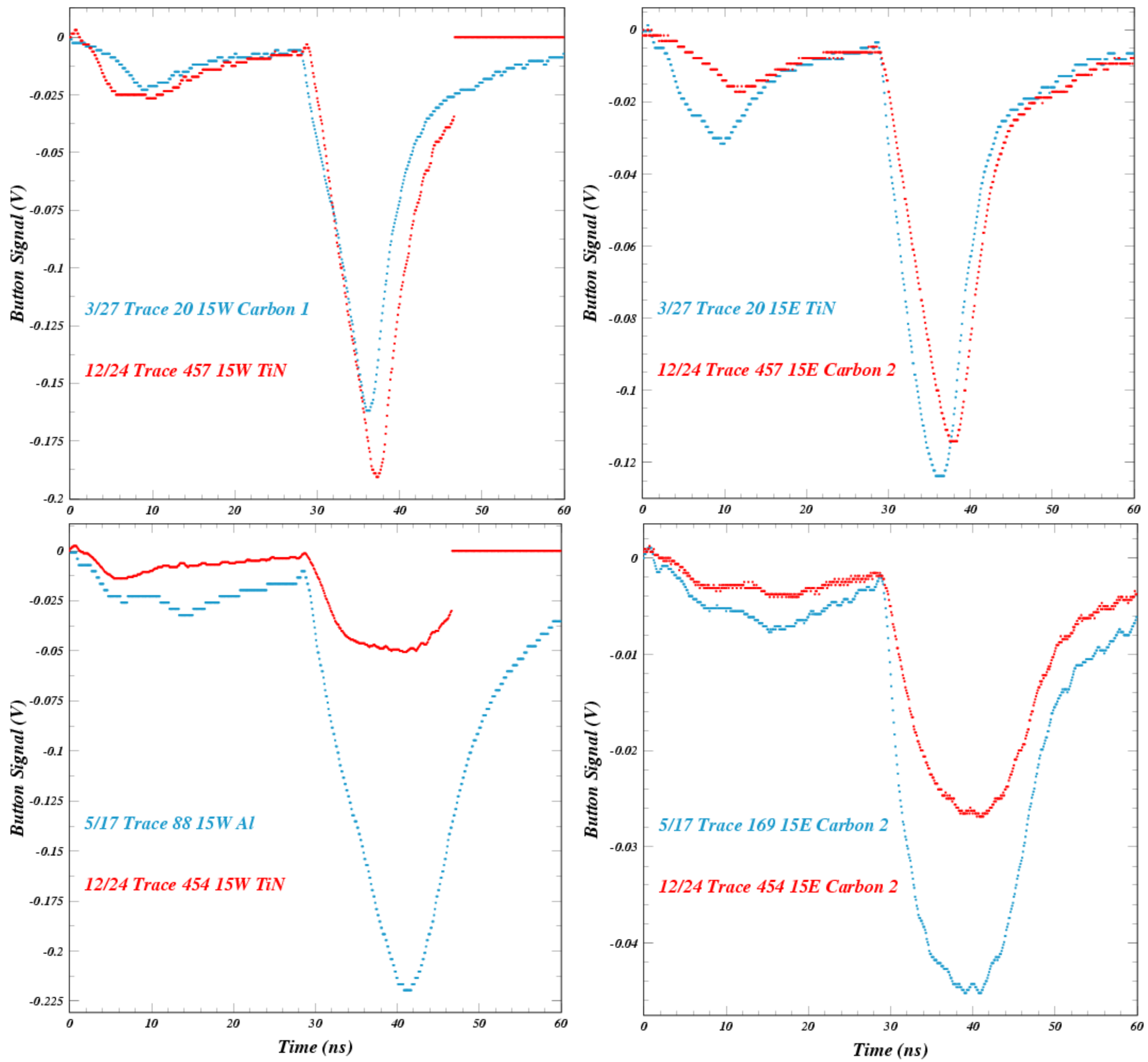
Vacuum Chamber Comparison Under Same Beam Conditions
5.3 GeV Positron Beam
Witness bunch with 28-ns spacing

15W | **15E**

The carbon coating suppresses high-energy photoelectrons compared to the TiN coating.

The q.e. for reflected photons and the SEY are both much smaller for TiN compared to Al.

The 3-mA TiN witness signal is a factor of 5 smaller than for 5 mA/bunch. *(see slide 13)*



5 mA/bunch

The results for the second carbon-coated chamber corroborate the high-energy photoelectron suppression relative to TiN observed with the first carbon chamber.

3 mA/bunch

The second carbon-coated chamber shows conditioning effects between 5/17 and 12/24, primarily for the quantum efficiency.

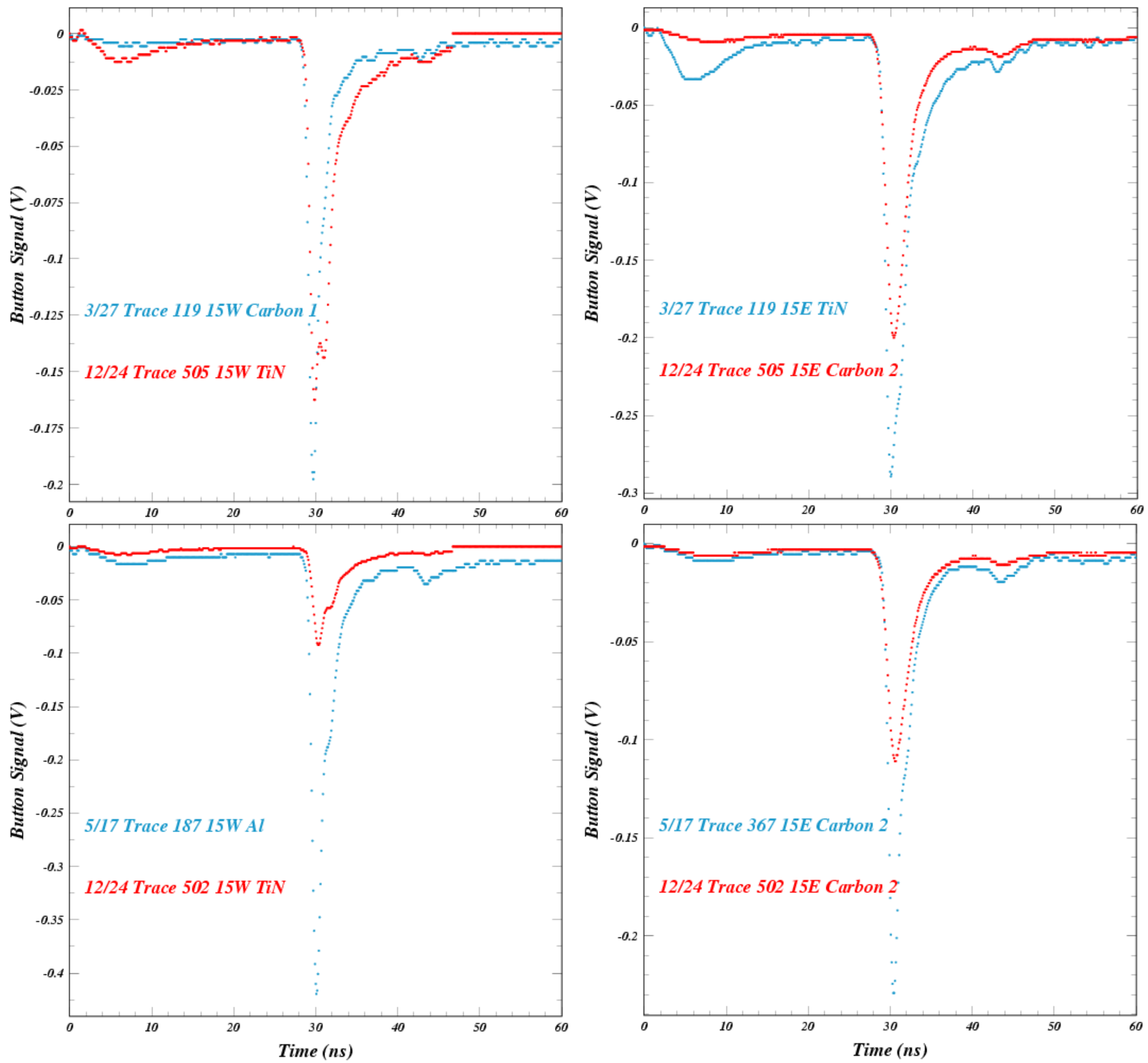
Vacuum Chamber Comparison Under Same Beam Conditions
5.3 GeV Electron Beam
Witness bunch with 28-ns spacing

15W | **15E**

5 mA/bunch

The carbon coating suppresses photoelectron production relative to the TiN coating, but the SEY may be higher.

Similar conclusions as for the first carbon-coated vacuum chamber.



3 mA/bunch

The measurements with the electron beam confirm the much smaller q.e. for reflected photons and SEY for TiN compared to Al found with the positron beam.

The electron beam measurements confirm the processing effect for the second carbon vacuum chamber observed with the positron beam.

Bunch Current Scan
5.3 GeV Positron Beam
Witness bunch with 14-ns spacing

The bunch current scan of 9/21 confirms the nonlinearity in the TiN signal observed in the vacuum chamber comparisons.

This strong nonlinearity of the witness bunch signal relative to bunch current will provide sensitivity to the energy dependence of the secondary yield .

Remark from MAP: The AREAS of the signals are linear with bunch current at the 15% level, as would be expected if primary photoelectrons dominated the signal, in which case the SEY curve will not affect it much. Simulations will tell.