Cornell University
Laboratory for Elementary-Particle Physics

Further Progress in Modeling the Time-Resolved Retarding Field Analyzer Measurements

--- Development of the Angular Acceptance Function ---

See talk at the Electron Cloud Meeting on 10 April 2013
and
IPAC'13
Modeling for the Time-Resolved Retarding Field Analyzer Measurements of Electron Cloud Buildup at CESRTA

Jared Ginsberg and Jim Crittenden

Electron Cloud Meeting

Cornell Laboratory for Accelerator-Based Sciences and Education

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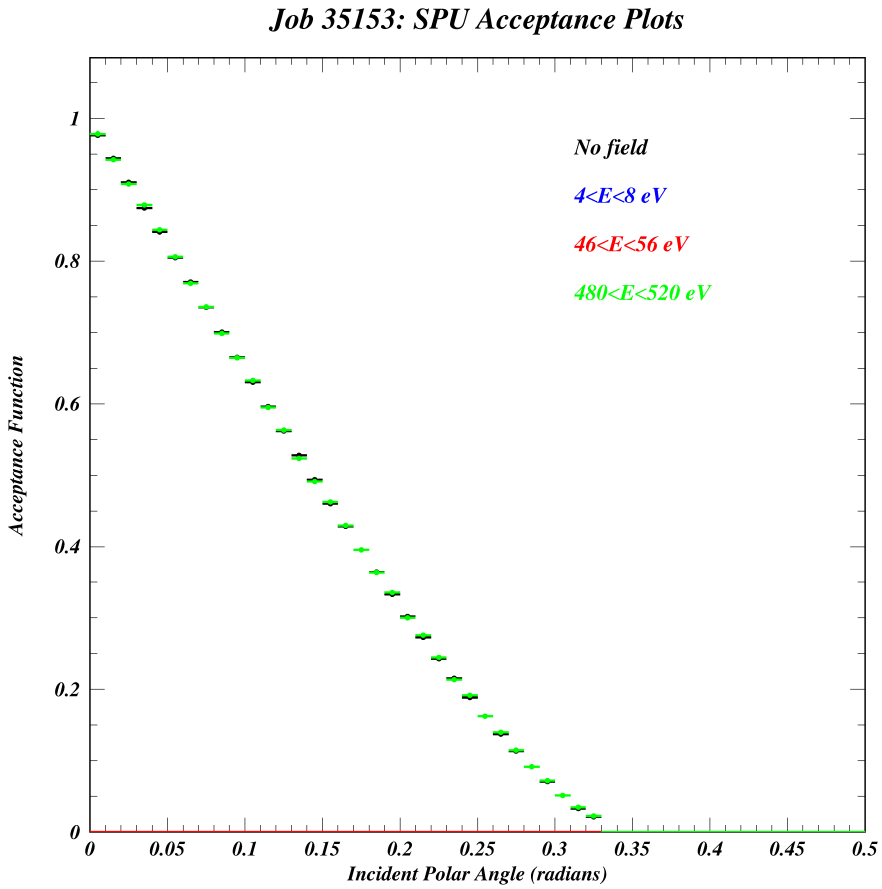
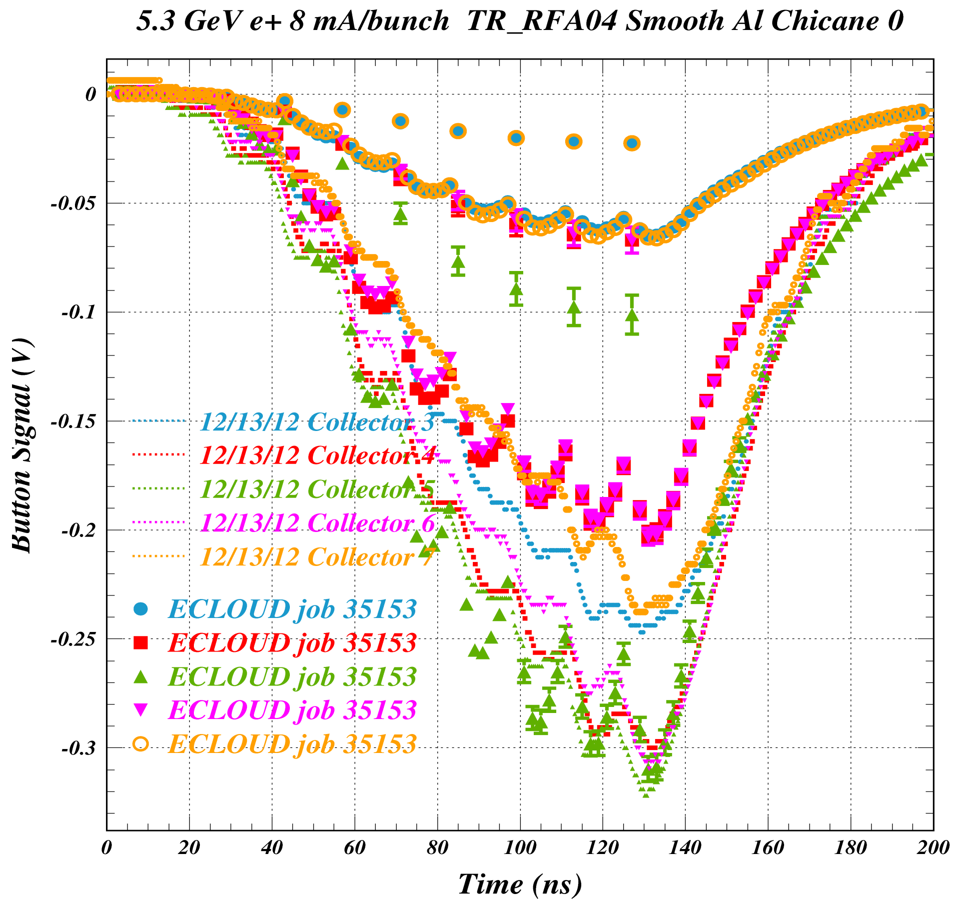
Relevant Definitions

- Constant *tanmax* (Θ_{max} *= ~0.33 radians)* is the diameter of a hole divided by the depth of the hole. This is the largest polar angle at which a particle can traverse the hole without necessitating the production of hole-secondaries.

- The 9 TR-RFA collectors are numbered from left to right as seen by the positron beam ("s" increasing), i.e. collector 5 is the central collector and collector 1 is on the outside of the ring. When I refer to the *outer collectors*, I am referring to those further from the center, for instance 2, 3, 7, or 8.

Why is the cloud "too narrow?"
Is the angle acceptance function too strict?





Using the angular acceptance function calculated separately by Joe Calvey (shown at left), the TR_RFA model shows good agreement for the central collector, number 5, only (at right, presented on 10 April, 2013). The signals modeled for the outside collectors are considerably smaller than we need.

Parameter Values / Process

The angular acceptance function was re-tuned for a field-free, 8mA/bunch scenario with the following values:

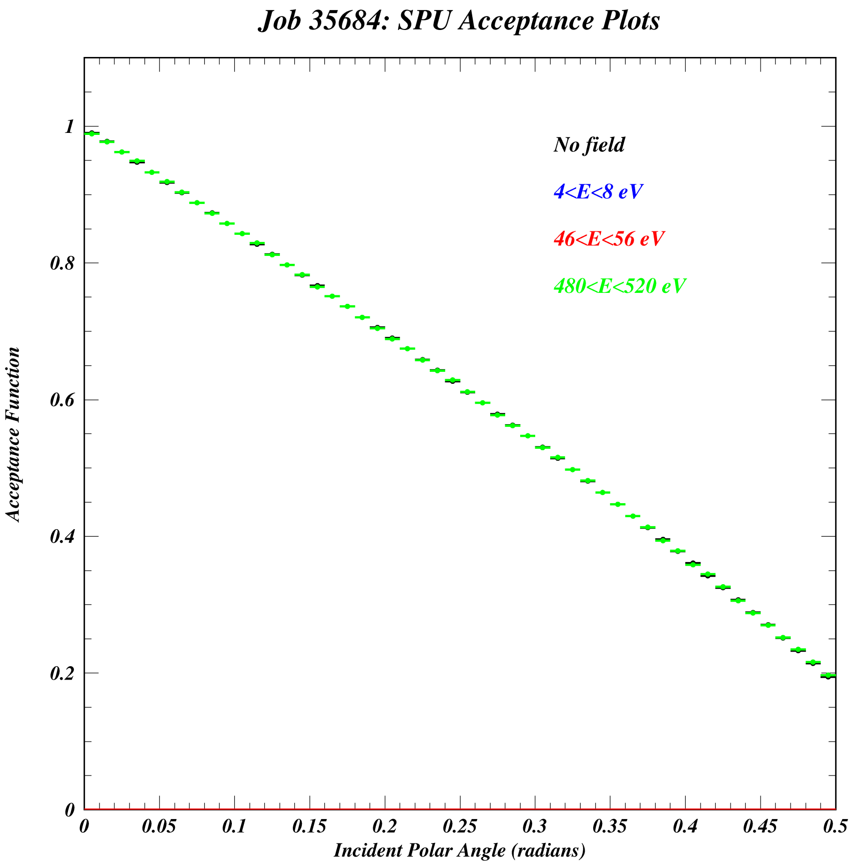
- Quantum Efficiency for Direct photons 6.5%
- Quantum Efficiency for Reflected photons 3.5%
- True SEY 1.2 / Elastic SEY 0.6 / Rediffused SEY 0.2
- Smooth Aluminum and TR_RFA 4 lattice from SYNRAD3D

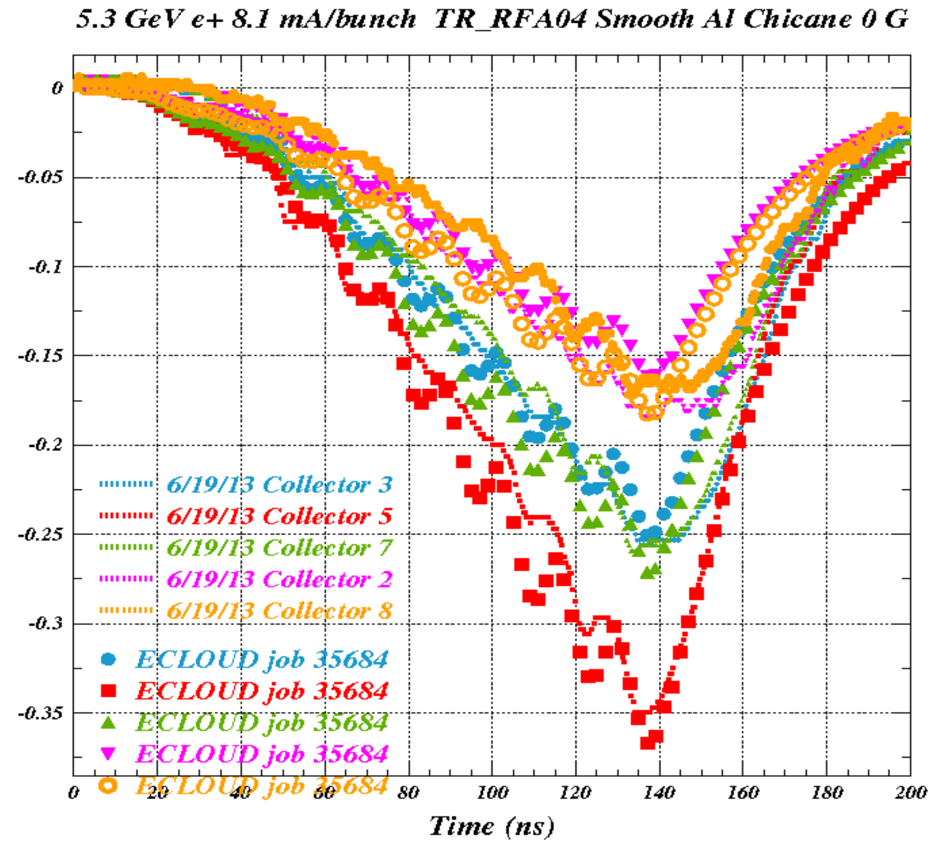
A few words/ brief overview of my process in general:

- Start with the IPAC13 collector 5 model from the previous slide
- Use SYNRAD3D (Direct control of Quantum Efficiencies is essential for field-on simulations, as we will see. IPAC13 model had zero reflectivity ==> field-on signal is zero.)
- Retune as above to regain a working model for collector 5. Quantum Efficiencies and SEY values determine both the amplitudes and time dependence of the signals.
- Extend to collectors 2/8 and eventually 1/9 using only the angular acceptance function

Doing so yields the following (after a lot of work):

Current State of the Model





The resulting acceptance function falls off much less quickly with increasing polar incidence. This substantially increases the signal sizes in the number 2, 3, 7, and 8 collectors. The extension of the angular acceptance function to angles larger than Θ_{max} greatly increases the strength of signals in outside collectors. All cloud electrons that enter a hole at these larger angles will collide with the walls of the hole at least once. Hole secondaries contribute significantly to the TR_RFA signals.

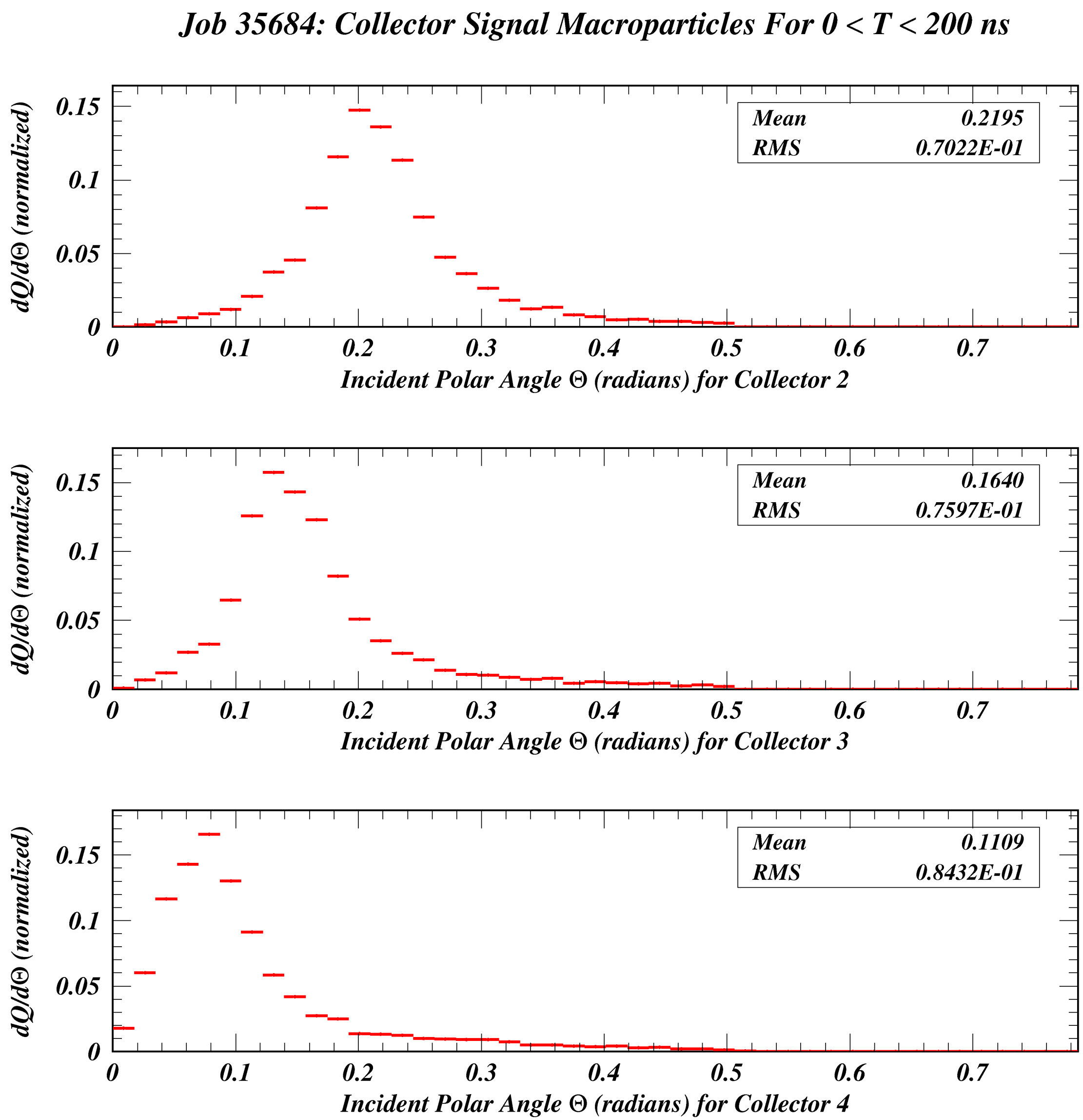
Corrected TR_RFA Angular Acceptance

The data shown represent the charge making it onto collectors 2-4 for varying incident polar angles. This effectively maps out the sections of the angular acceptance function most relevant to each collector.

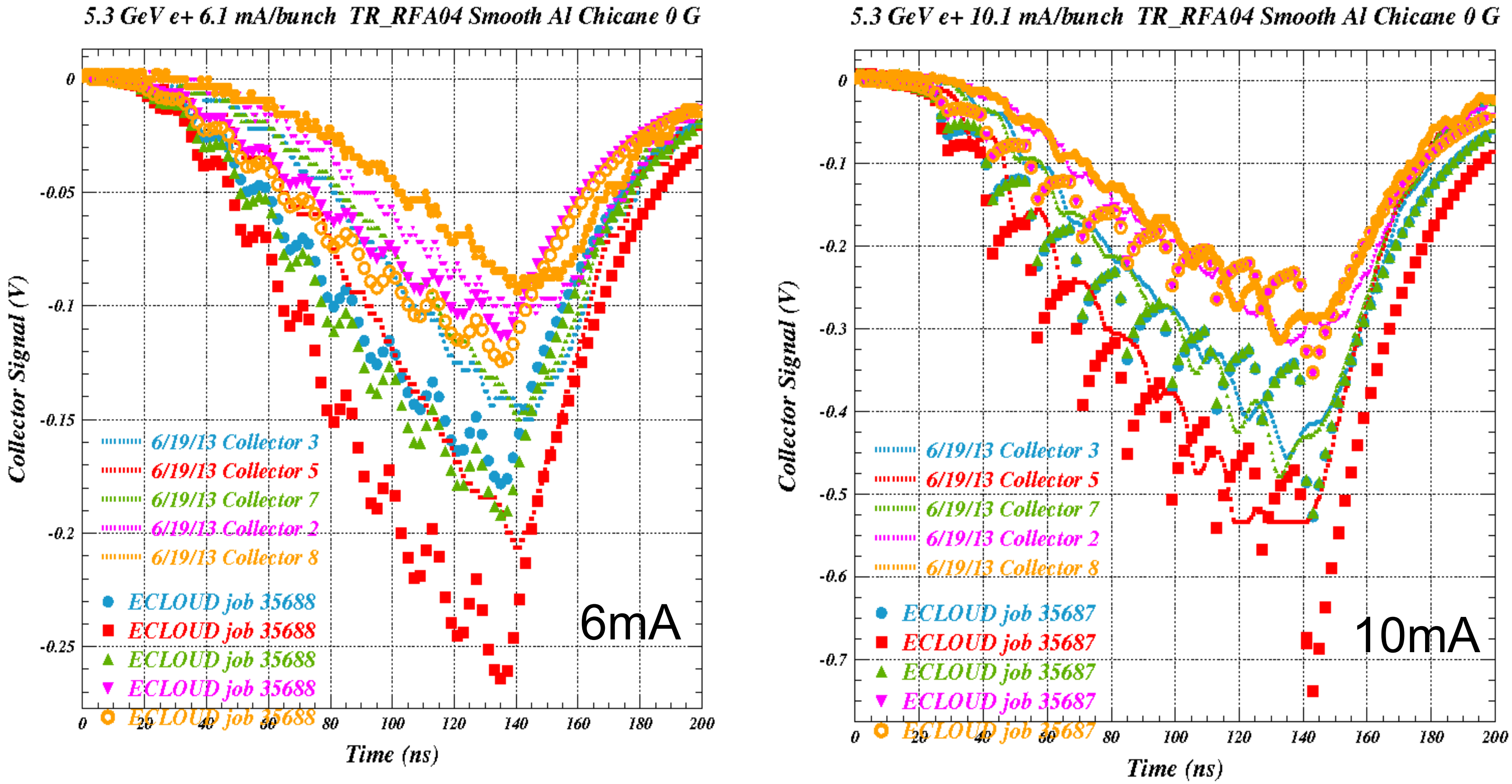
Each successive collector has a peak angular acceptance ~.05 radians different than the previous.

The contribution beyond Θ_{max} appears small, but proved to be essential for reproducing the signals in the outer collectors.

Collector 5 (not shown) is peaked close to 0.0 radians, as expected.



Extension to Bunch Currents of 6 and 10 mA



Our hope was to design an angular acceptance scheme that would be robust for changes in the bunch current away from the 8mA/bunch for which it was designed. Here we see that the model handles an increase in bunch current to 10mA/bunch well, maintaining both the relative sizes as well as the overall size and timing. Lowering the current to 6 mA however, we see that the model breaks down, with a size that is ~20% too large across all collectors.

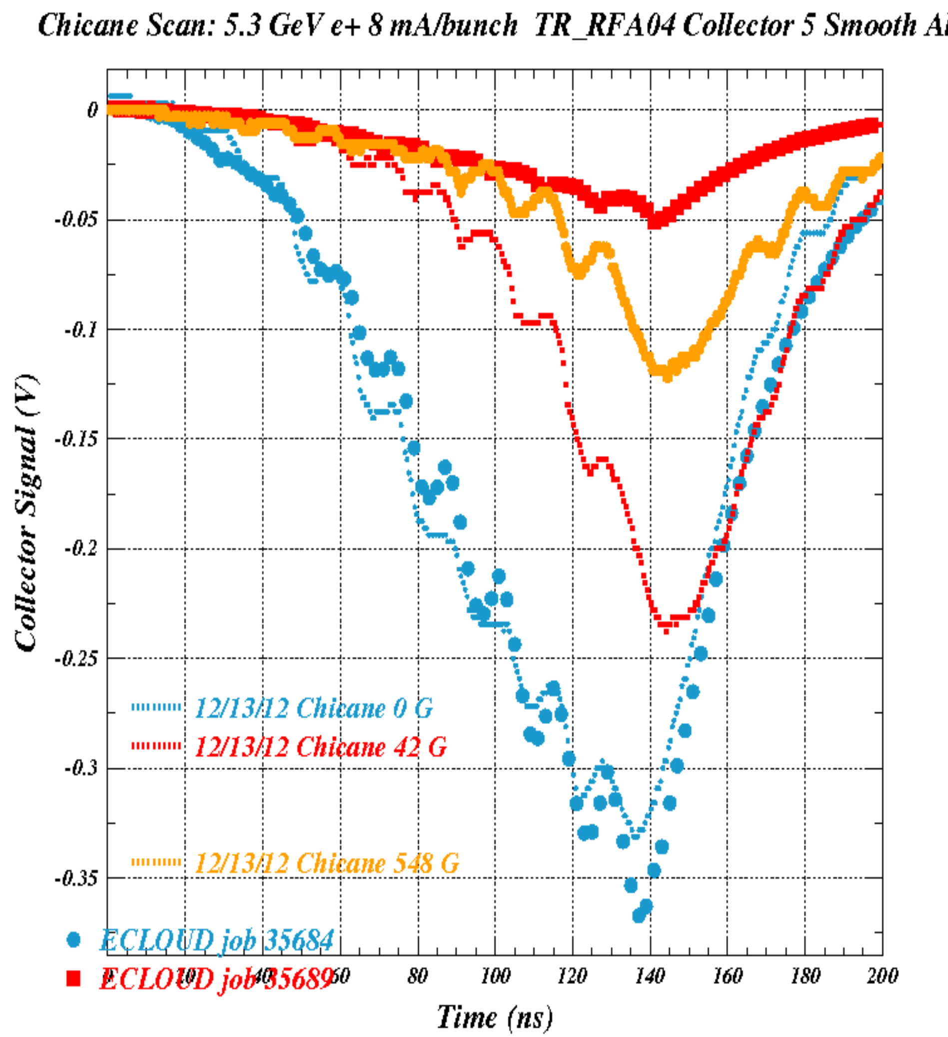
Turning on the field

In addition to stability of the model under bunch current changes, we would like it to also handle having a dipole field present.

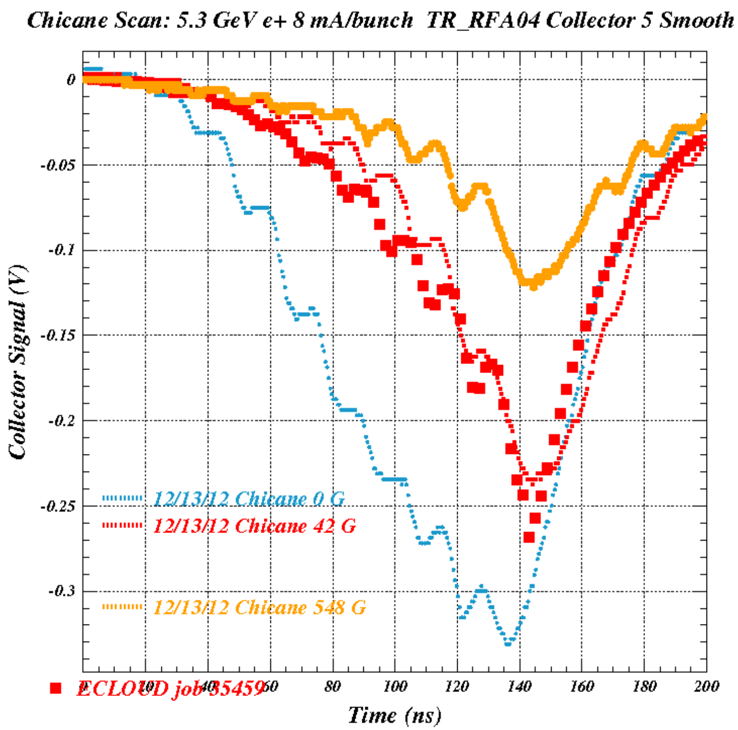
First of all, the slight differences you may notice between the field free data presented here and in previous slides is due to the fact that this data was taken in December '12, when the Chicane Scan was performed, rather than in June.

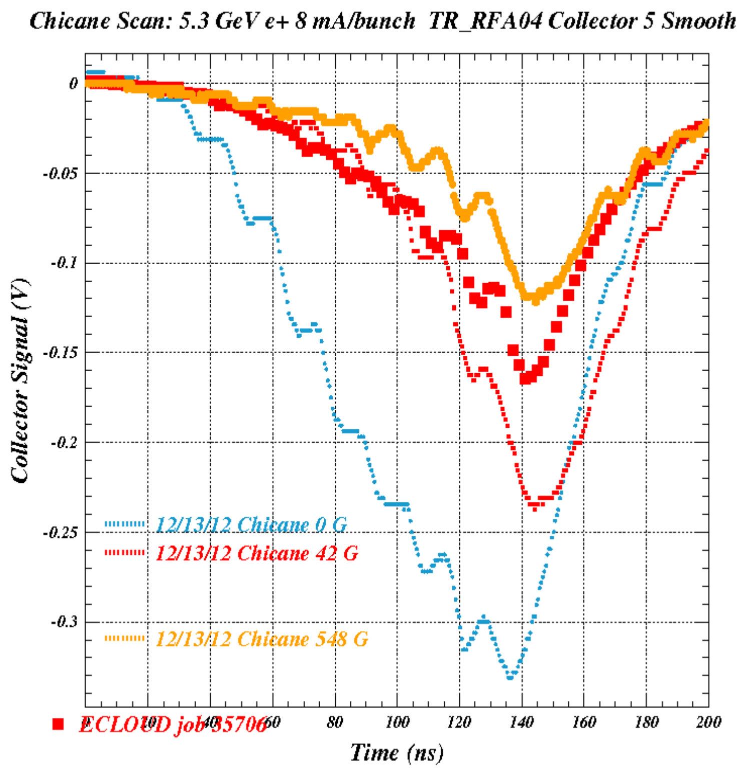
This field-on acceptance model accounts for the horizontal motion of a particle traveling through a hole due to its cyclotron motion, and recalculates a value for Θ_{max}, then uses the new angular acceptance function.

Comparison of the 42-G model to the data (red points) indicates that the B-field dependence of the acceptance in the model is too strong.



Prior Standalone Field-On Study





In a separate, prior study altogether, I had investigated the field-on case, the most promising result of which is shown here. This study led me to values of:

- Q.E. Reflected 6%, (Completely insensitive to QED, thus necessitating the use of Synrad3D)
- True SEY 1.8
- And was run with the older ang. acc. function

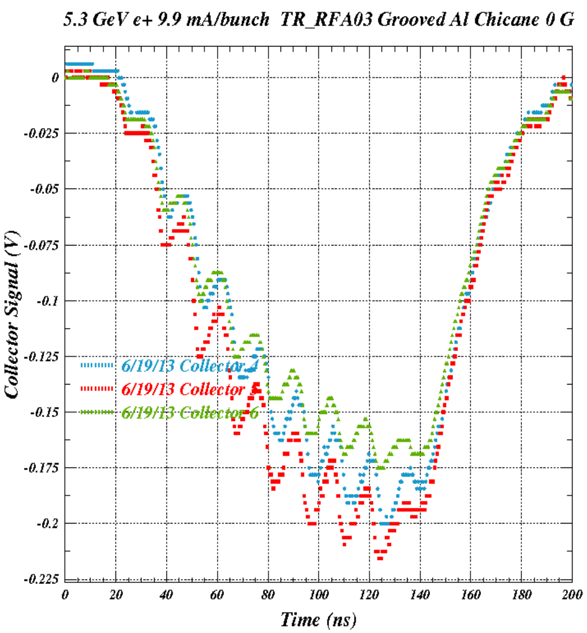
Both of these values are higher than for our new field-free case

Here I have rerun the dipole field case using the up-to-date acceptance function and the SEY/QER that gave agreement in the past...

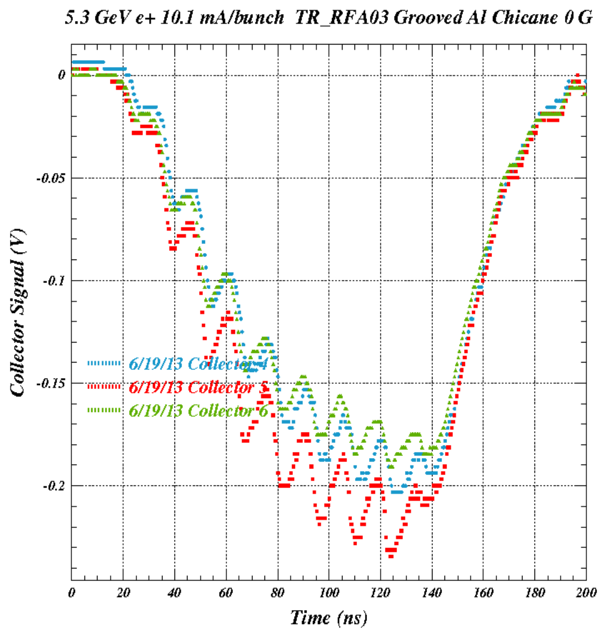
With our new acceptance function, even raising the SEY and QER to the old values is not sufficient to return to the success we once had. There is thus an unresolved discrepancy here between high-QER field-on agreement, and low-QER field-off agreement.

Side Project: Beam Position

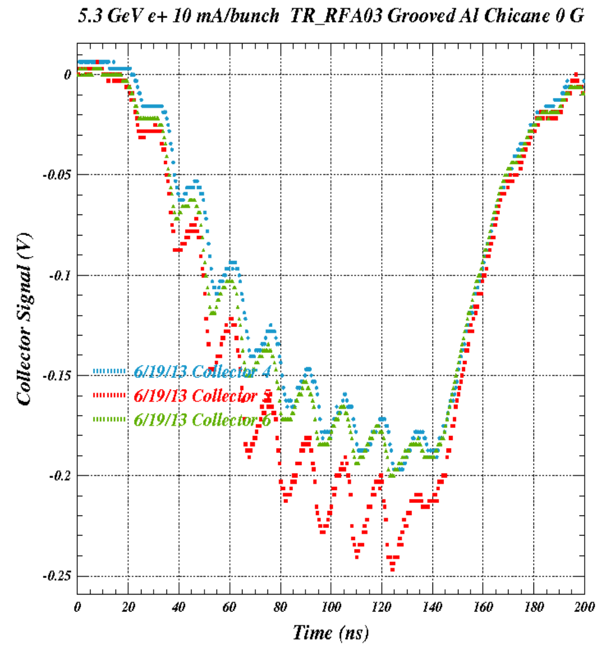
- 2 mm (positive hbump)



0 mm



+2 mm



(Note: June '13 data for Grooved Aluminum)

For a time, I was interested in studying how horizontal displacements of the beam affected the left-right asymmetry of collector signals. In this example from TR_RFA #3, we see that beam bumps on the order of a few millimeters can change the relative sizes of the signals we study. However, this dependence is weaker than the model dependence on parameters such as the QE or SEY.

Need to repeat model study of beam position dependence with the new angular acceptance.

Conclusions

Following the progress made on the TR_RFA model leading up to the IPAC '13 paper, there were three important extensions to be made

- *Extension from a single, central collector, to all 9 collectors*
    - The most successful we've been at extending the model. The changes that were introduced to the angular acceptance function significantly improved the relative amplitudes of the signals of neighboring collectors

- *Extension from the 8mA/bunch (for which the model is tuned) to a range of currents, higher and lower*
    - We've seen promising results when raising the bunch current, and less exciting results lowering it. Some investigation into this is required, as well as identifying the cause of the 10mA/bunch large oscillations in the shape

- *Move from a field free case to a range of field values*
    - This is still the study that plagues us the most. We have a totally separate, acceptable model, that can't yet be reconciled with the other two studies.