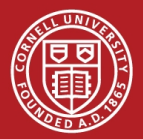


Cornell University
Laboratory for Elementary-Particle Physics

Measurement and Modeling of

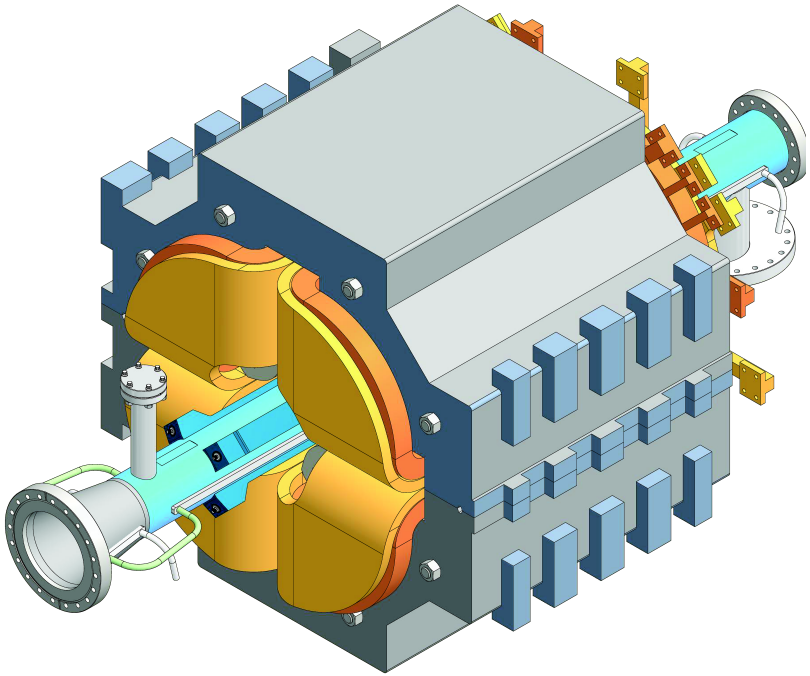
Electron Cloud Trapping in a CESR Quadrupole

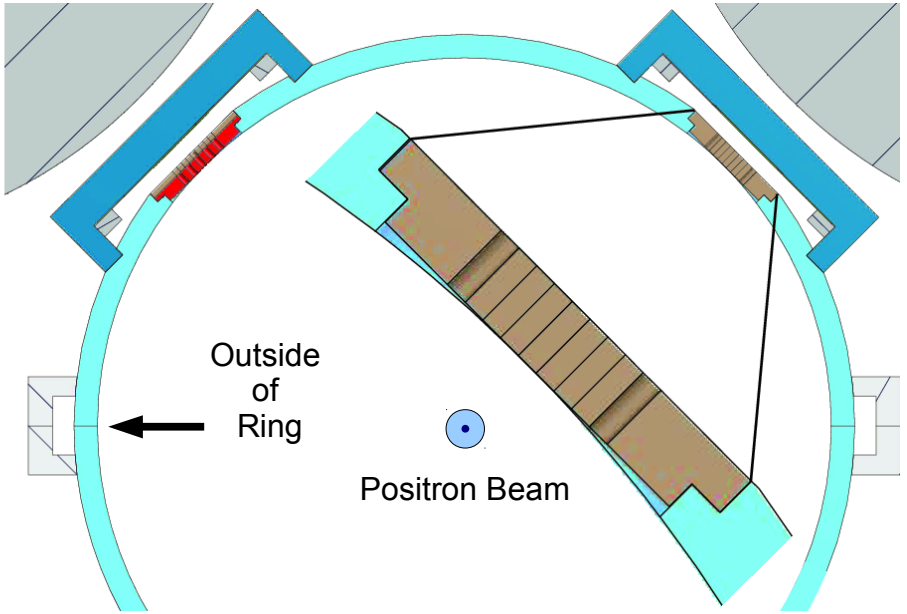
Jim Crittenden & John Sikora

CESRTA General Meeting

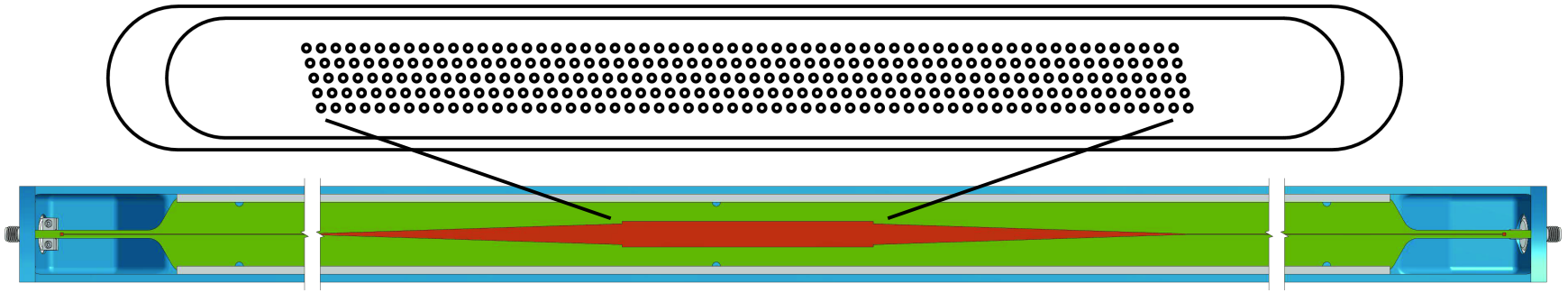
19 November 2013

Shielded Pickup Detector in Quadrupole Q48W





300 holes Diameter: 0.79 mm Depth 2.4 mm Transparency 22%
Width: 7 mm Length: 94 mm



Observation of Electron Trapping

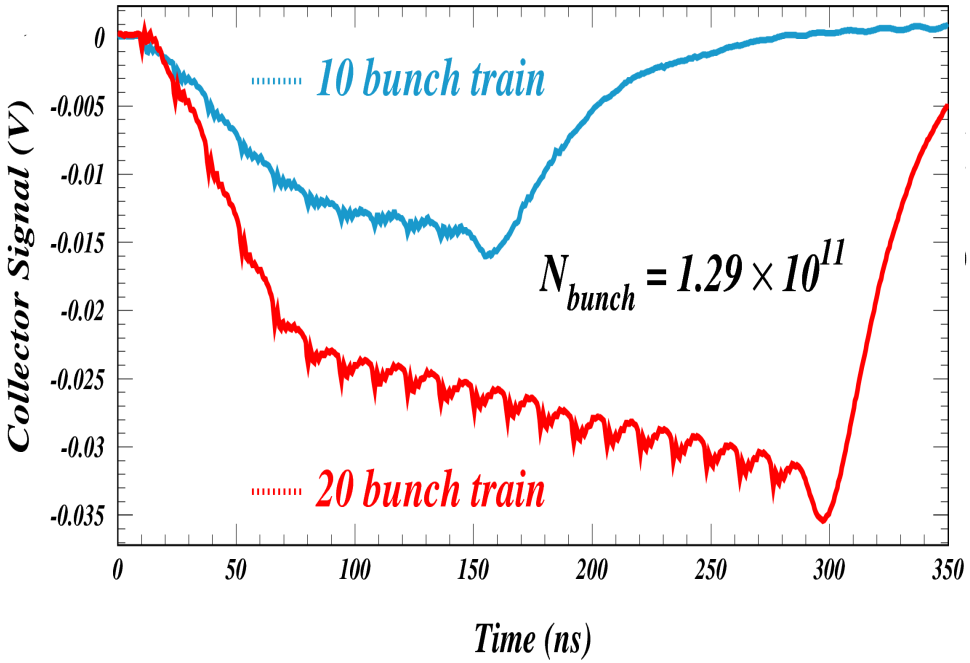
Observation of Electron Trapping in a Positron Storage Ring

M.G. Billing, J. Conway, E.E. Cowan, J.A. Crittenden, J. Lanzoni, Y. Li, C.S. Shill, J.P. Sikora and K. Sonnad

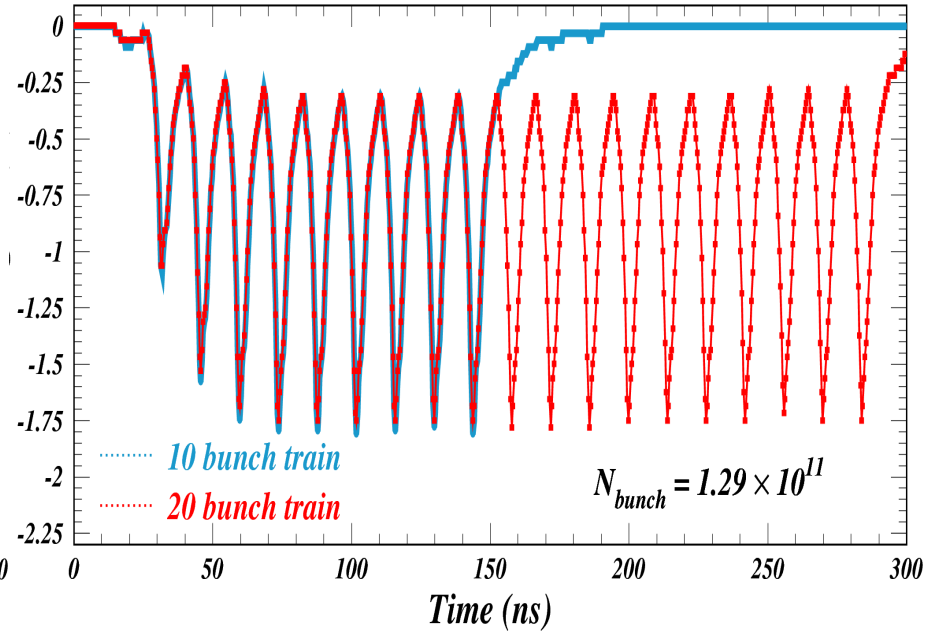
ArXiv: 1309.2625v2, submitted 9/10/2013

Comparison of shielded-pickup signals for 10-bunch and 20-bunch trains

Quadrupole magnetic field (Q48W)



No magnetic field (15E)



How do the first ten bunches of a 20-bunch train know that they are in a 20-bunch train?

Electron cloud buildup modeling code ECLOUD

* Originated at CERN in the late 1990's
* Application for PS, SPS, LHC, KEK, RHIC,5 ILC ...
* Under active development at Cornell since 2008
* Successful modeling of CESRTA tune shift measurements
* Interactive shielded pickup model implemented in 2010
* Full POSINST SEY functions added as option 2010-2012
* Flexible photoelectron energy distributions added 2011
* Synrad3D photon absorption distribution added 2011
* Quadrupole shielded pickup model added 2013

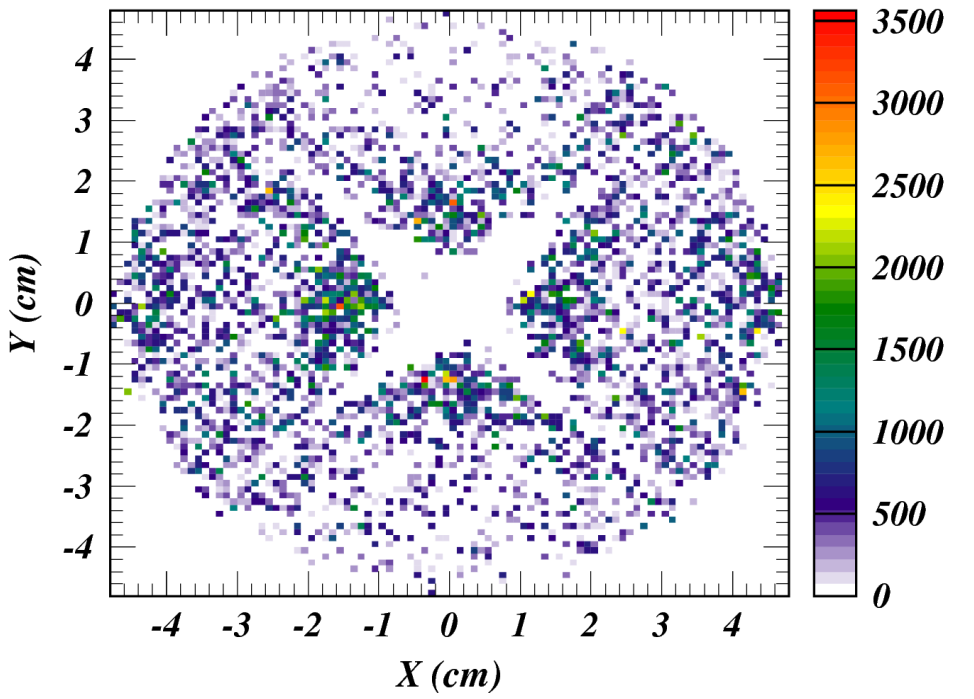
I. Generation of photoelectrons
   A) Production energy, angle
   B) Azimuthal distribution (v.c. reflectivity)

II. Time-sliced cloud dynamics
   A) Cloud space charge force
   B) Beam kick
   C) Magnetic fields

III. Secondary yield model
   A) True secondaries (yields > 1!)
   B) Rediffused secondaries (high energy)
   C) Elastic reflection (dominates at low energy)

IV. Shielded pickup models
   A) Acceptance vs incident angle, energy
   B) Signal charge removed from cloud
   C) Non-signal charge creates secondaries

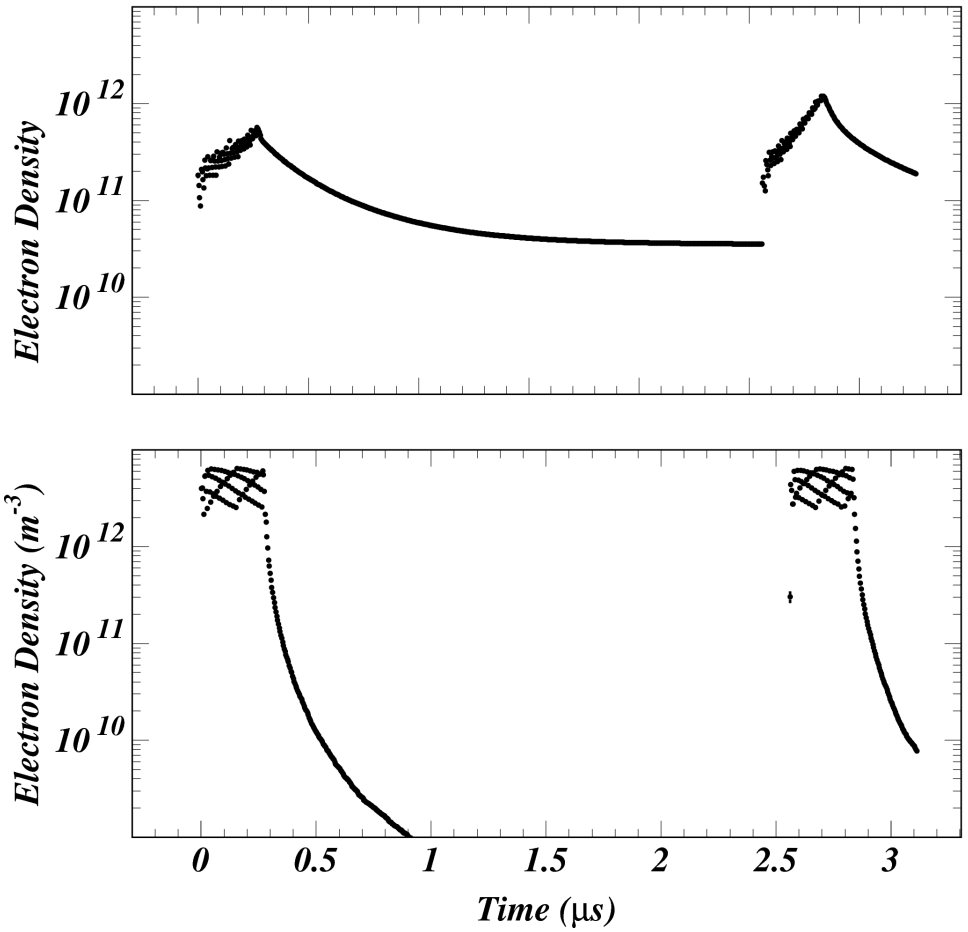
Cloud snapshot just prior to the second passage of the train



The intersection of field lines with the vacuum chamber wall provide “escape zones” including the point where SPU signal particles enter the detector.

The source points of the signal particles are also at those positions. So the magnitude of the signal depends directly on the distribution of scattered photons which produce photoelectrons on the vacuum chamber wall at those points.

Is electron trapping expected under these beam conditions? Ask the model.



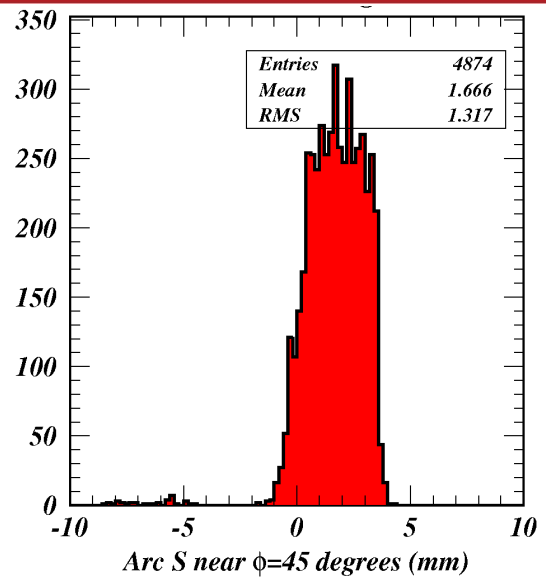
Quadrupole magnetic field (Q48W)

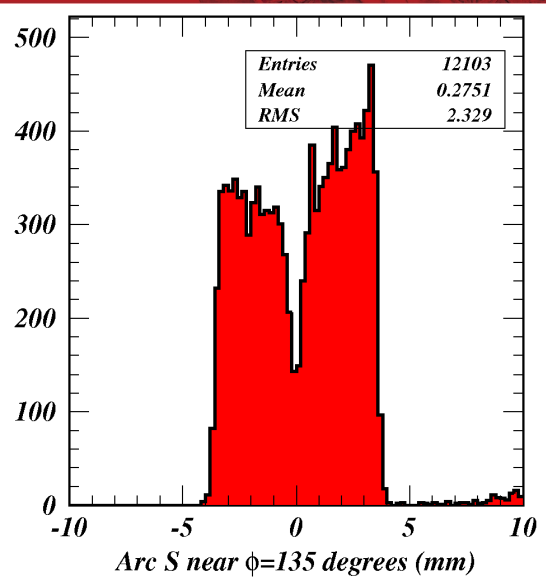
No magnetic field (15E)

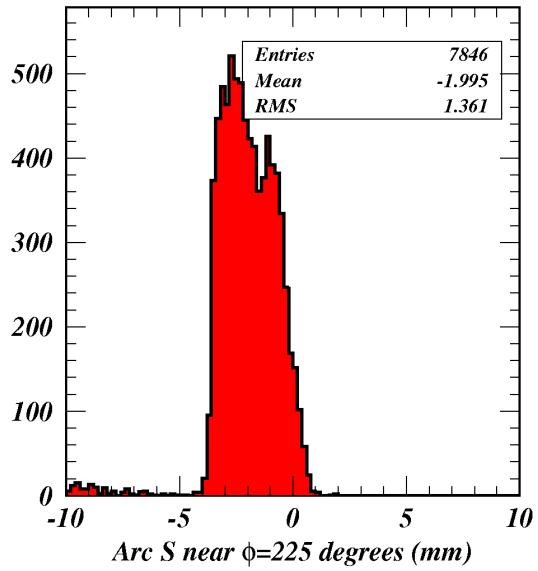
Yes.

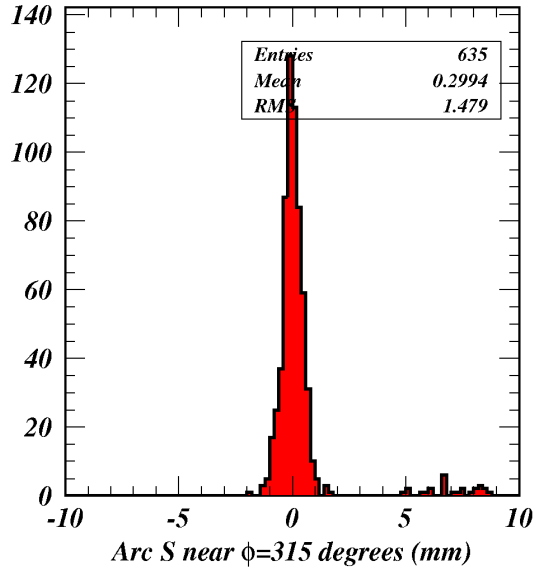
About 5% of the cloud built up by the train survives until the next passage of the train.

Electrons producing the QSPU signal -- Azimuthal Source Points --







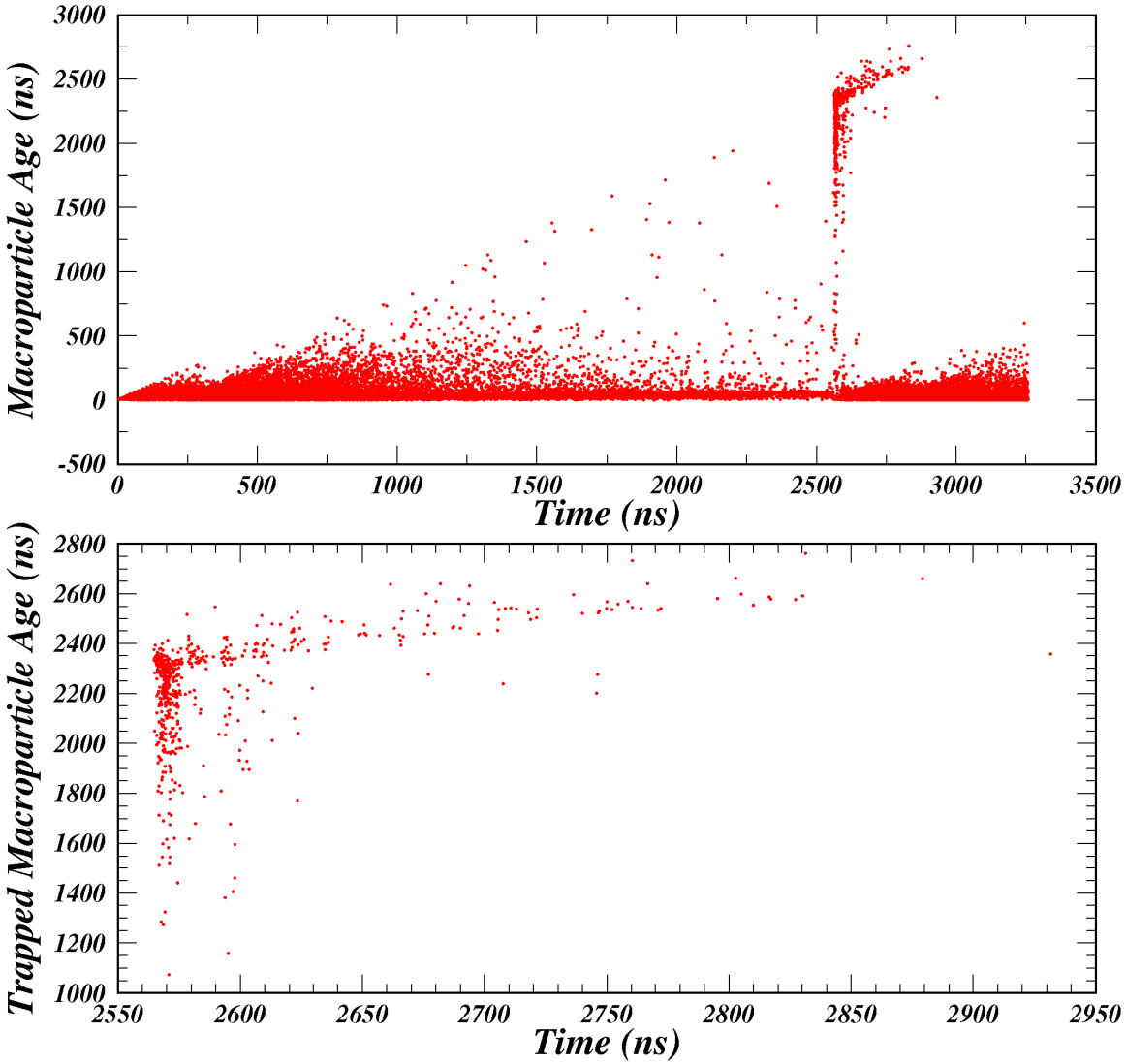


Signal electrons come from narrow regions connected to the shielded pickup position by magnetic field lines.

The regions are about 5 mm wide except for the one directly across the vacuum chamber, which is only about 3 mm side. The most likely source point is in front of the SPU itself over a region 8 mm wide.

The contribution of a narrow central portion of this nearby region is reduced due to losses on the opposite side of the vacuum chamber.

Electrons producing the QSPU signal -- Trapped electrons --

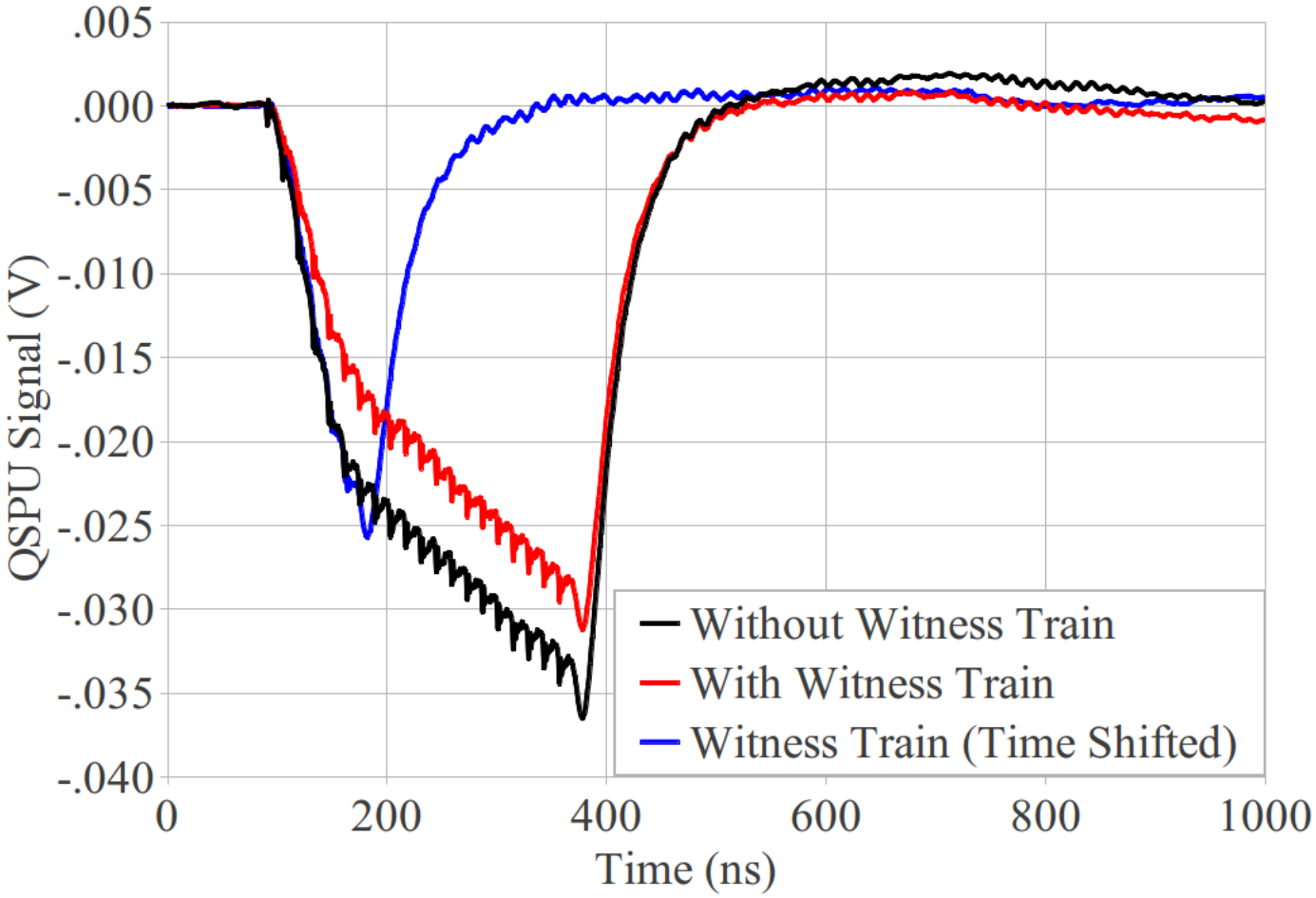


The primary contribution to the SPU signal during the first few bunches of the second passage of the bunch train is from macroparticles that are more than a microsecond old.

After the first 50 ns the signal is produced primarily by electrons born at the end of the first train passage.

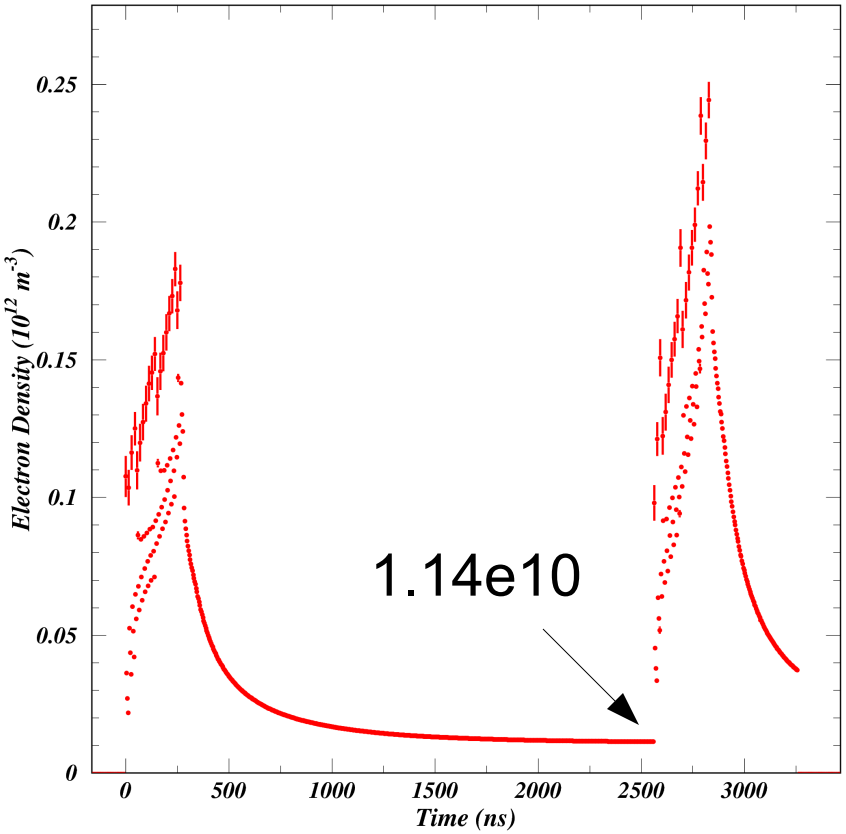
Rich future measurement program

Clearing trapped electrons by means of an intermediate train of bunches
(JPS measurements from Tuesday before last 11/5)

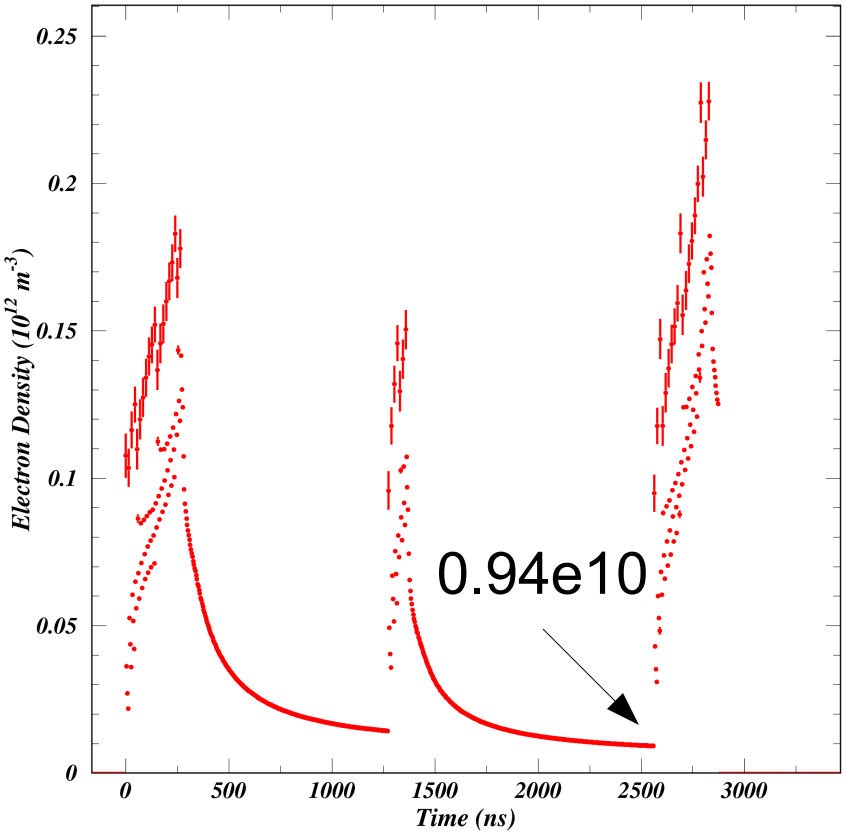


Is the clearing effect expected under these beam conditions? Ask the model.

Without witness train



With witness train



Yes.
But not for other clearing-train delays. Measurements underway.