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Electron Cloud Measurements Using a Shielded Pickup in a Quadrupole at CESRTA*

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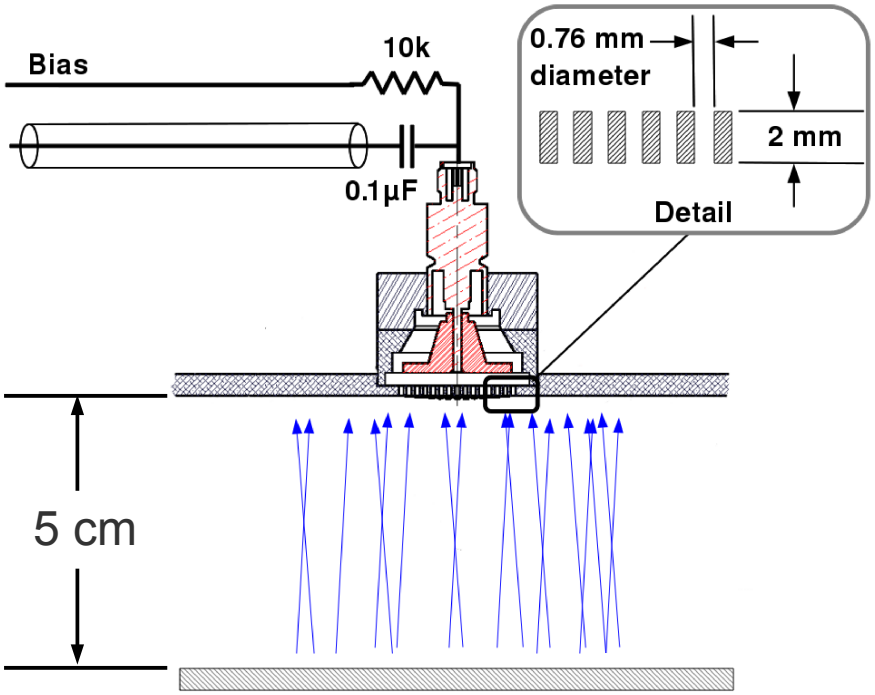
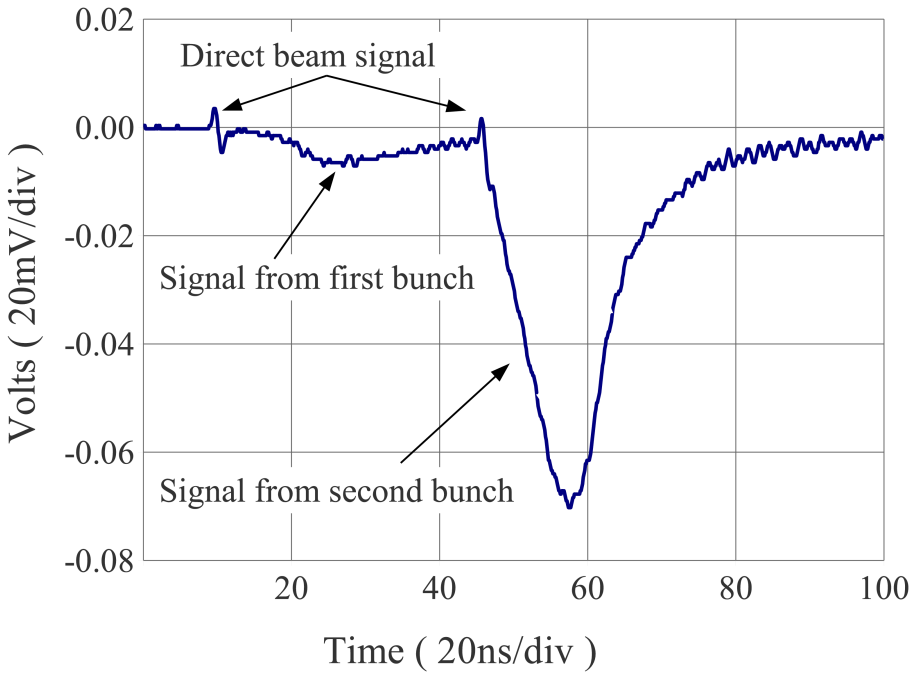
Shielded Pickup (SPU)

Shielded Pickup [SPU] Detector (Field Free)



Signal from Two Bunches

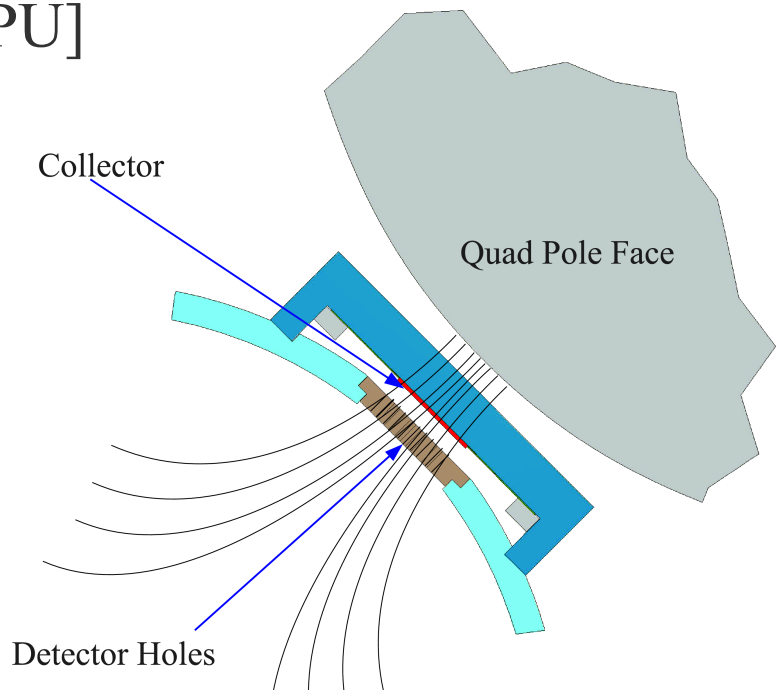


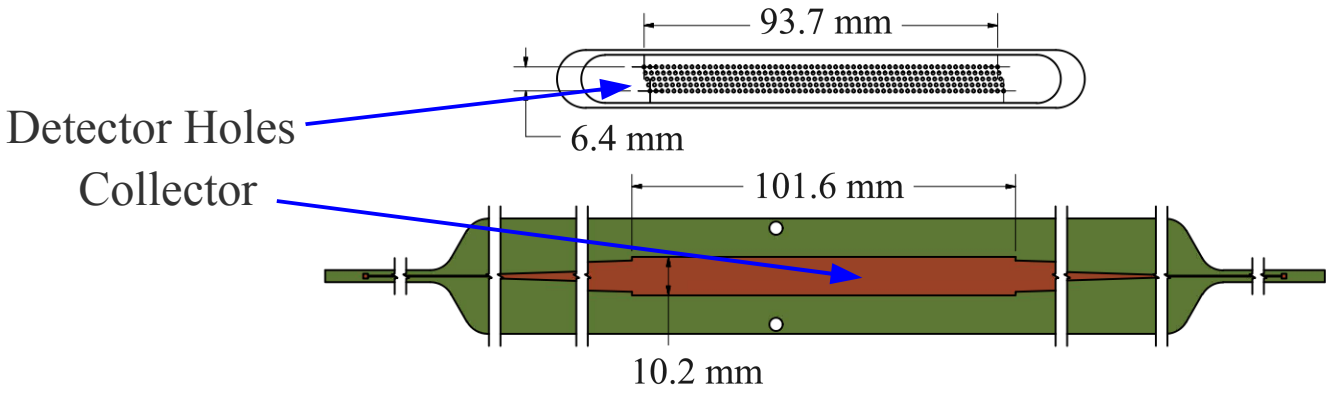
- Samples the flux of cloud electrons onto the vacuum surface.
- Bunches accelerate electrons into the detector.

Quad Shielded Pickup (QSPU)

Quadrupole Shielded Pickup [QSPU] Detector (7.4 T/m)

- Based on SPU design
- Aligned on pole face
- Longitudinal center of quad.
- Holes shield collector from direct beam signal

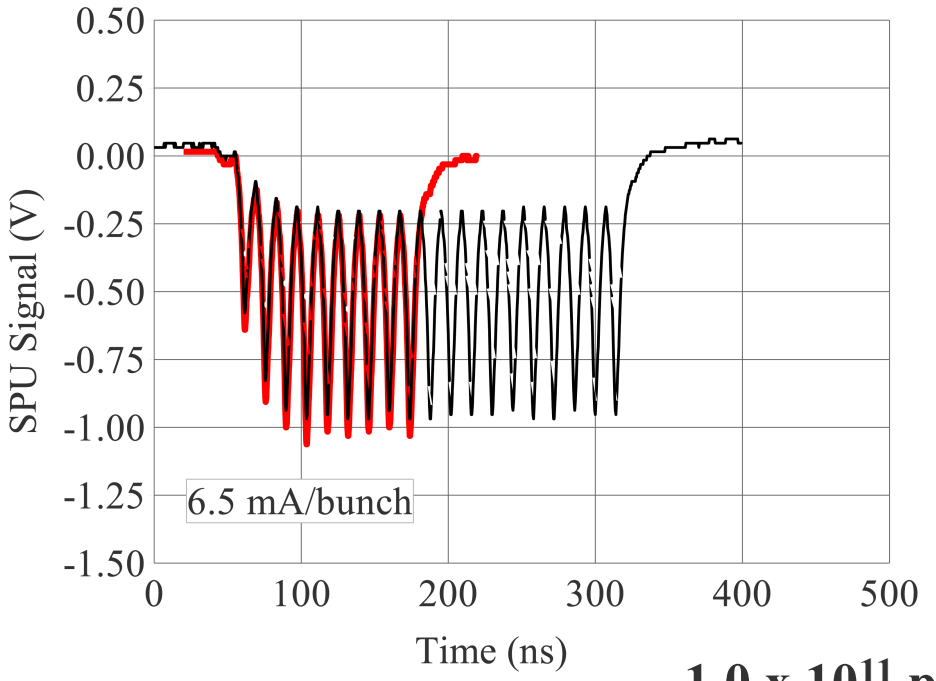




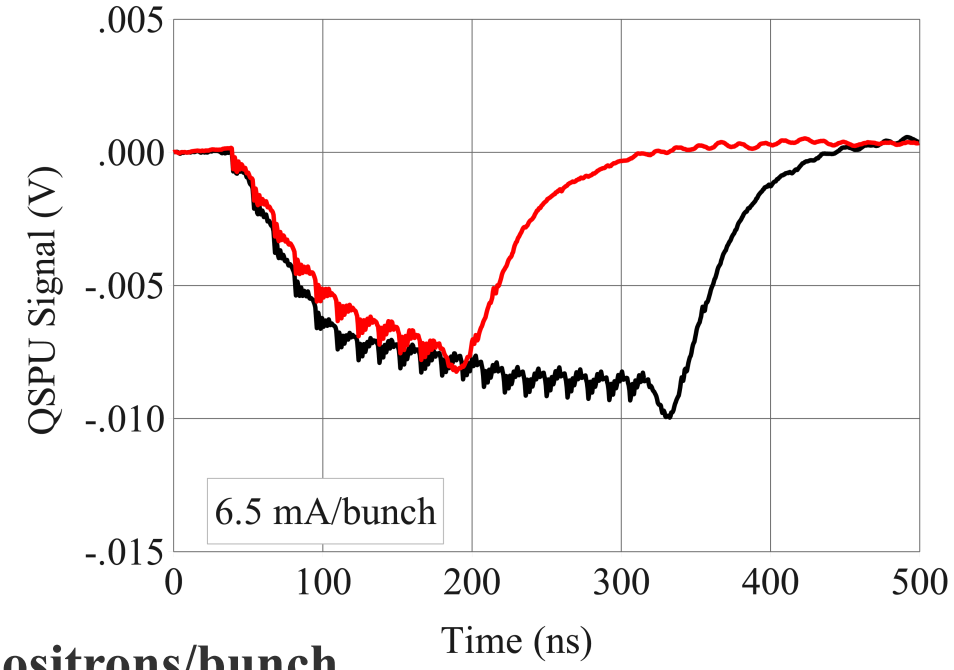
Comparison of SPU and QSPU Signals

Overlay of Signals from 10-Bunch and 20-Bunch Trains

SPU (Field Free)



QSPU (7.4 T/m)



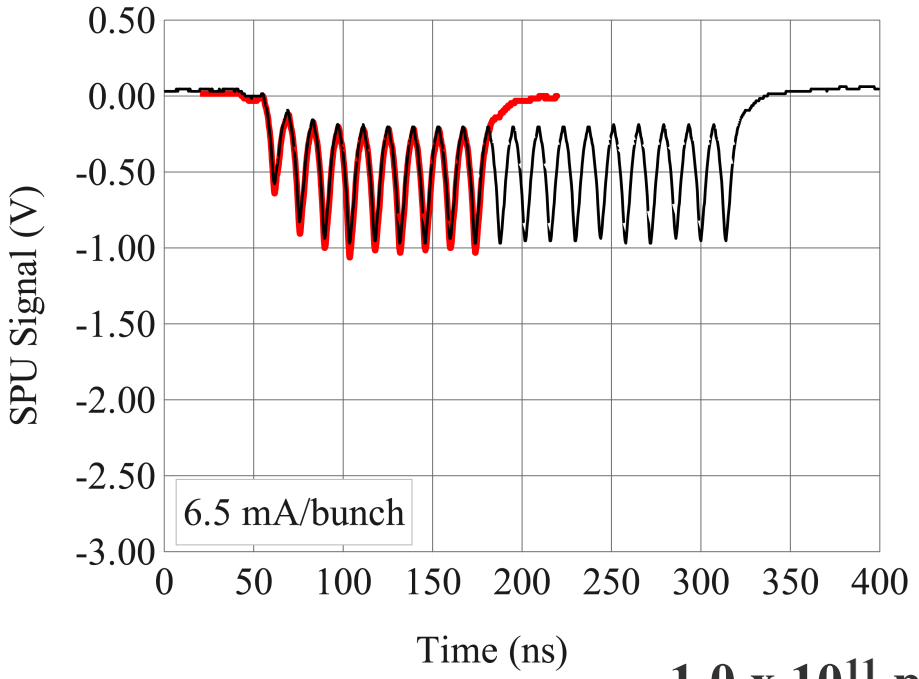
1.0×10^{11} positrons/bunch

- Train lengths: 126 & 266 ns; Turn = 2562 ns; Cloud lifetime ~100 ns
- The first 10 bunches should have the same signal, independent of train length (since the cloud is gone with the arrival of the first bunch).

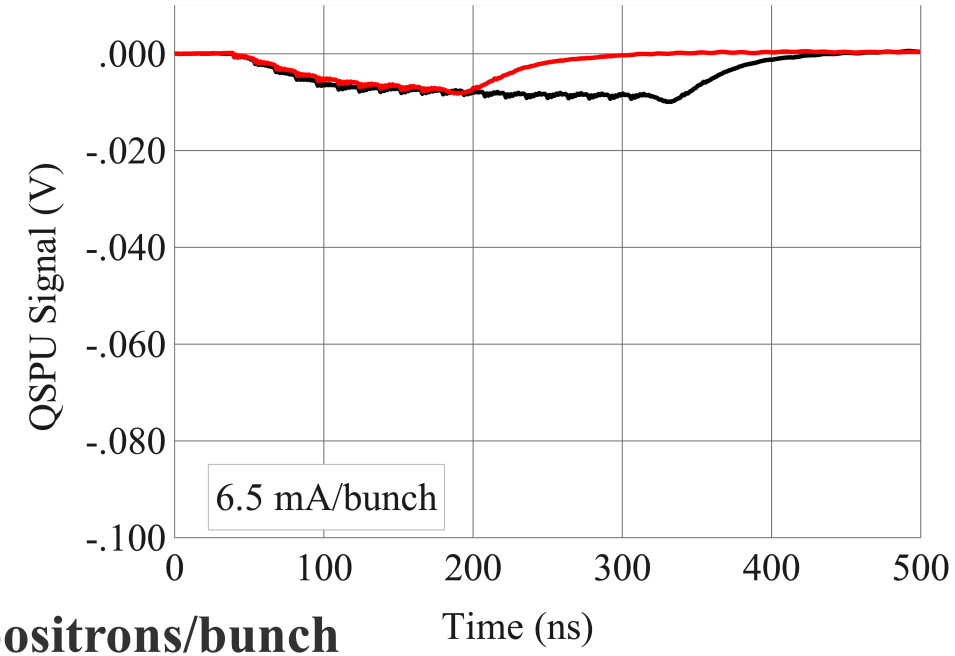
Comparison of SPU and QSPU Signals

Overlay of Signals from 10-Bunch and 20-Bunch Trains

SPU (Field Free)



QSPU (7.4 T/m)



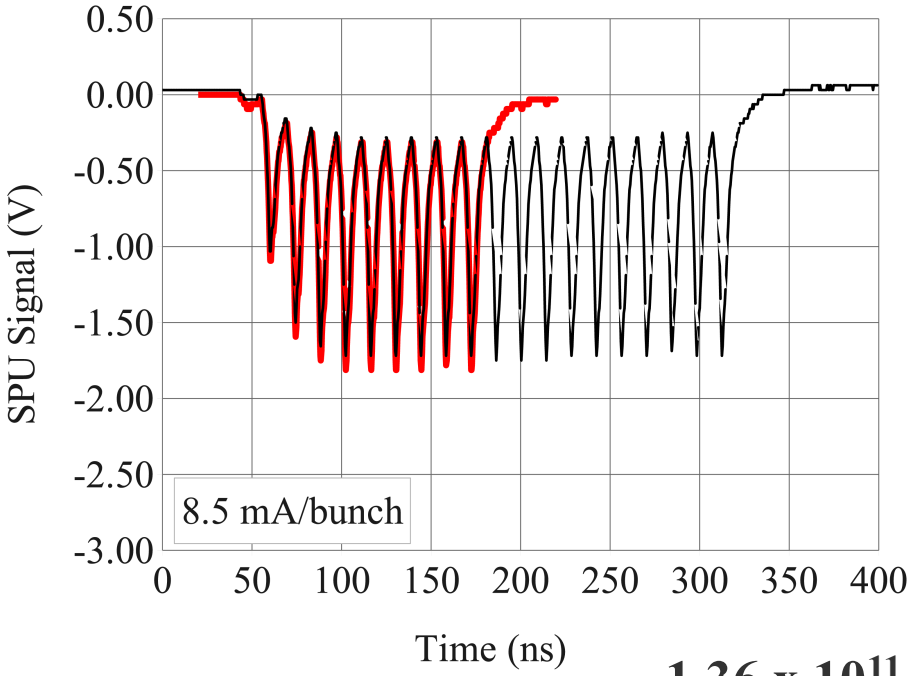
1.0×10^{11} positrons/bunch

- The same plots on different scales
- Now increase the bunch charge

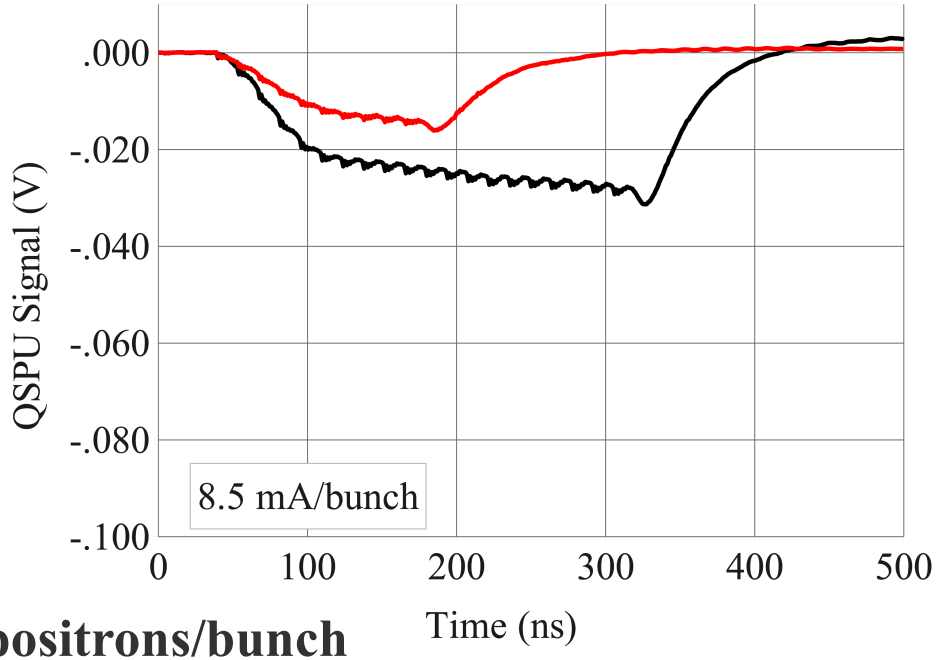
Comparison of SPU and QSPU Signals

Overlay of Signals from 10-Bunch and 20-Bunch Trains

SPU (Field Free)



QSPU (7.4 T/m)



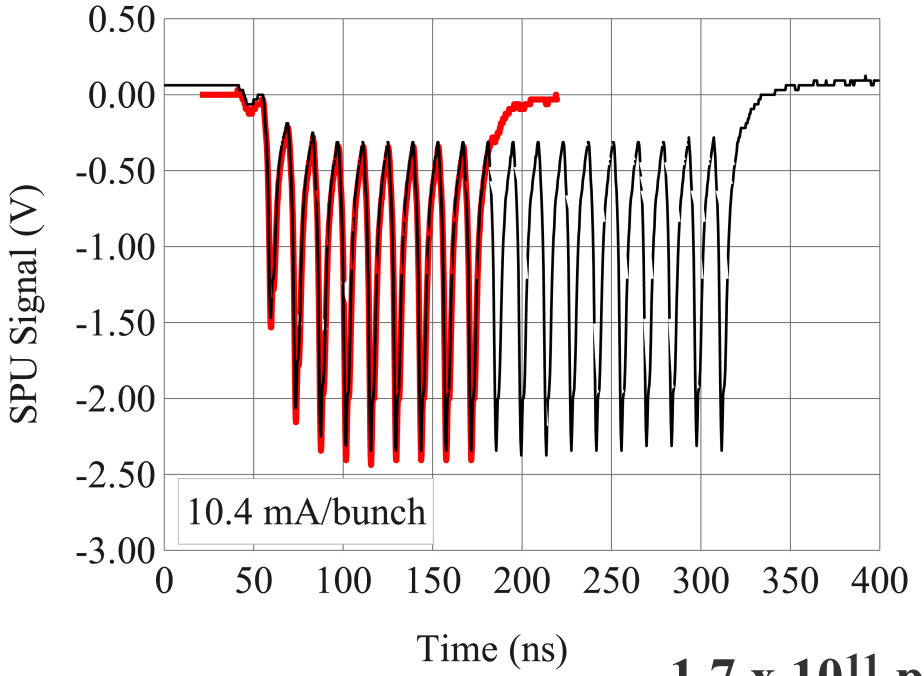
1.36×10^{11} positrons/bunch

- At higher bunch charge, the first 10 bunches are still the same in the field free detector, but very different in the QSPU.

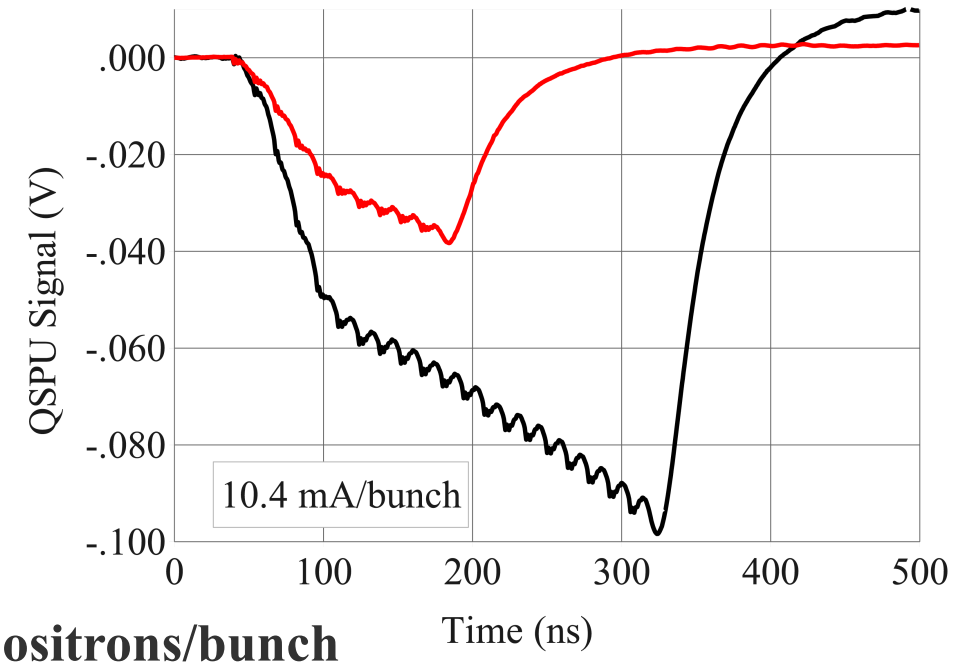
Comparison of SPU and QSPU Signals

Overlay of Signals from 10-Bunch and 20-Bunch Trains

SPU (Field Free)



QSPU (7.4 T/m)



1.7×10^{11} positrons/bunch

- This only makes sense if some of the electron cloud persists in the quadrupole for the 2.5 μs turn.
- 20-bunch train can access an additional reservoir of charge that remains trapped in the quadrupole from the previous turn.

Summary and Future Work

- We have constructed a device to make time resolved measurements of electron cloud in a quadrupole.
- In comparing data from this detector with a similar device in a field free region, there are significant differences that indicate trapping of the cloud in the quadrupole field.
- Further experiments and simulations are needed to better understand this effect.
- Additional information including initial simulation results have been submitted to Physical Review Letters for consideration. A draft pre-print is available in the physics archive:

arXiv.org/abs/1309.2625

arXiv:1309.2625 [physics.acc-ph]

Thank you for your attention.

For additional information on shielded pickups, simulations and electron cloud:

• M.G. Billing, *et al.,* "Observation of Electron Cloud Trapping in a Positron Storage Ring", arXiv:1309.2625 [physics.acc-ph], 2013.

• J.A. Crittenden and J.P. Sikora, "Electron Cloud Buildup Characterization Using Shielded Pickup Measurements and Custom Modeling Code at CESRTA", in Proc. of ECLOUD'12, La Biodola, Isola d'Elba, Italy, June 5-8 2012, arXiv:1307.4013 [physics.acc-ph].

• L.F. Wang, H. Fukuma,S. Kurokawa, and K. Oide, Phys. Rev. E **66**, 036502 (2002).

•J.A. Crittenden, *et al*., "Electron Cloud Modeling Results for Time-resolved Shielded Pickup Measurements at CESRTA," in Proc. of PAC'11, New York, NY, USA, August 2011, WEP142, p.1752, (2011).

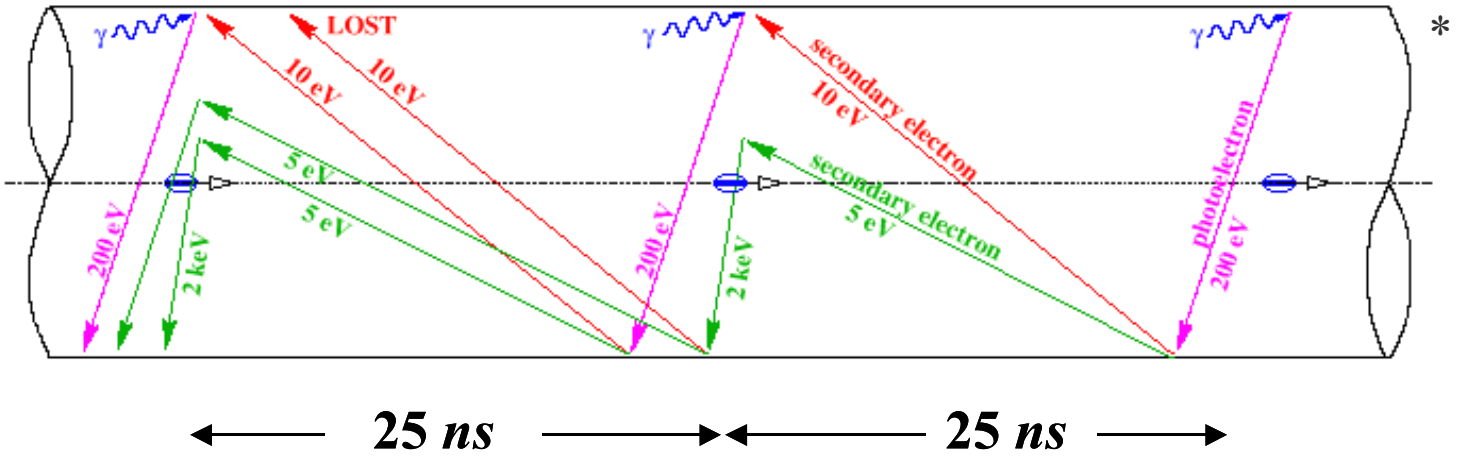
• "The CESRTA: Phase I Report," Tech. Rep. CLNS-12-2084, LEPP, Cornell University, Ithaca, NY (Jan. 2013). http://www.lns.cornell.edu/public/CLNS/2012/

•M.A. Furman and M.T.F. Pivi, "Probabilistic model for the simulation of secondary electron emission", PRST-AB 5, 124404 (2002).

Time-resolved EC Density Measurements

Extra Slides Follow

Electron Cloud Buildup

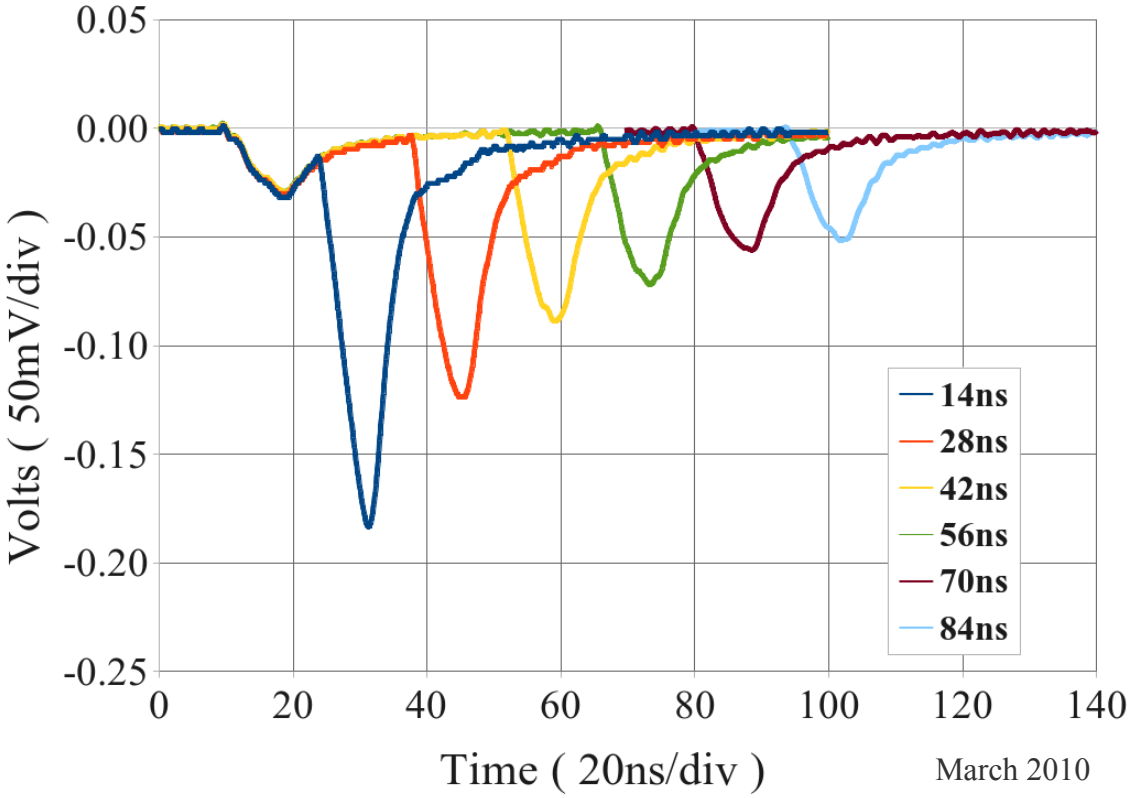


- In an electron/positron storage ring, electron cloud is produced primarily by photo-electrons from synchrotron radiation.
- Photo-electrons produce secondary electrons.
- Additional bunches accelerate electrons that are already present, as well as producing their own photo-electrons.

*Sketch of the electron cloud effect for the LHC by F. Ruggiero

SPU: 2-Bunch Measurements

SPU 2-Bunch Data with Different Spacings

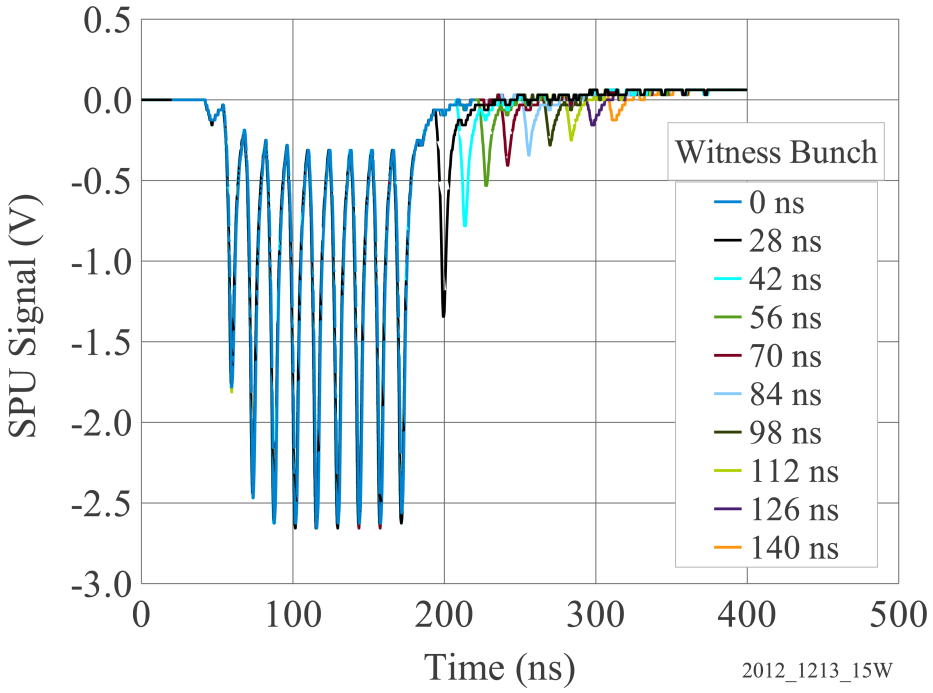


- An overlay of SPU 2-bunch signals with different spacings shows the decay of the cloud produced by the first bunch.

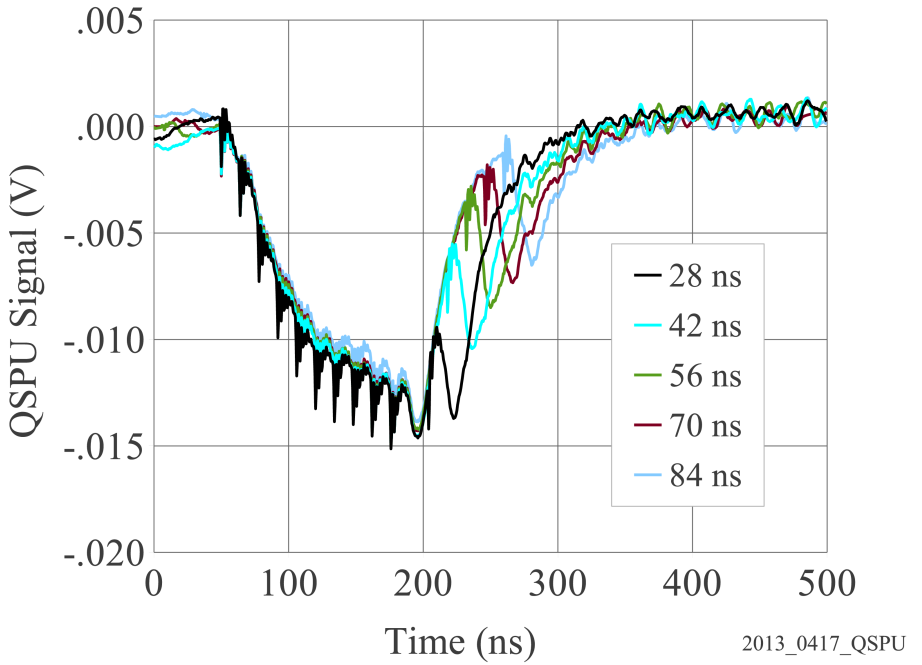
Comparison of SPU and QSPU Signals

Witness Bunches After a 10-bunch Train Positrons

SPU (Field Free)

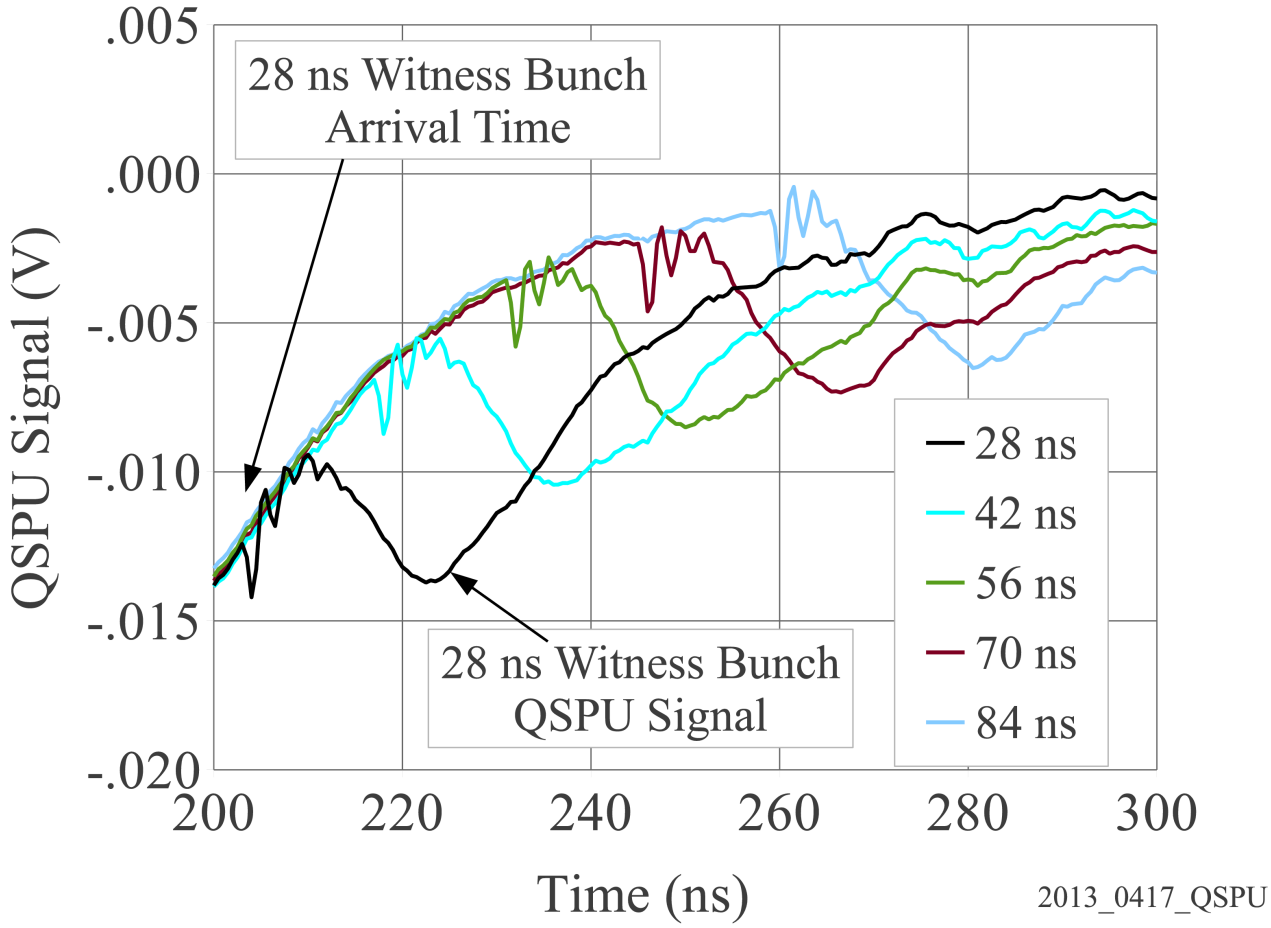


QSPU (7.4 T/m)



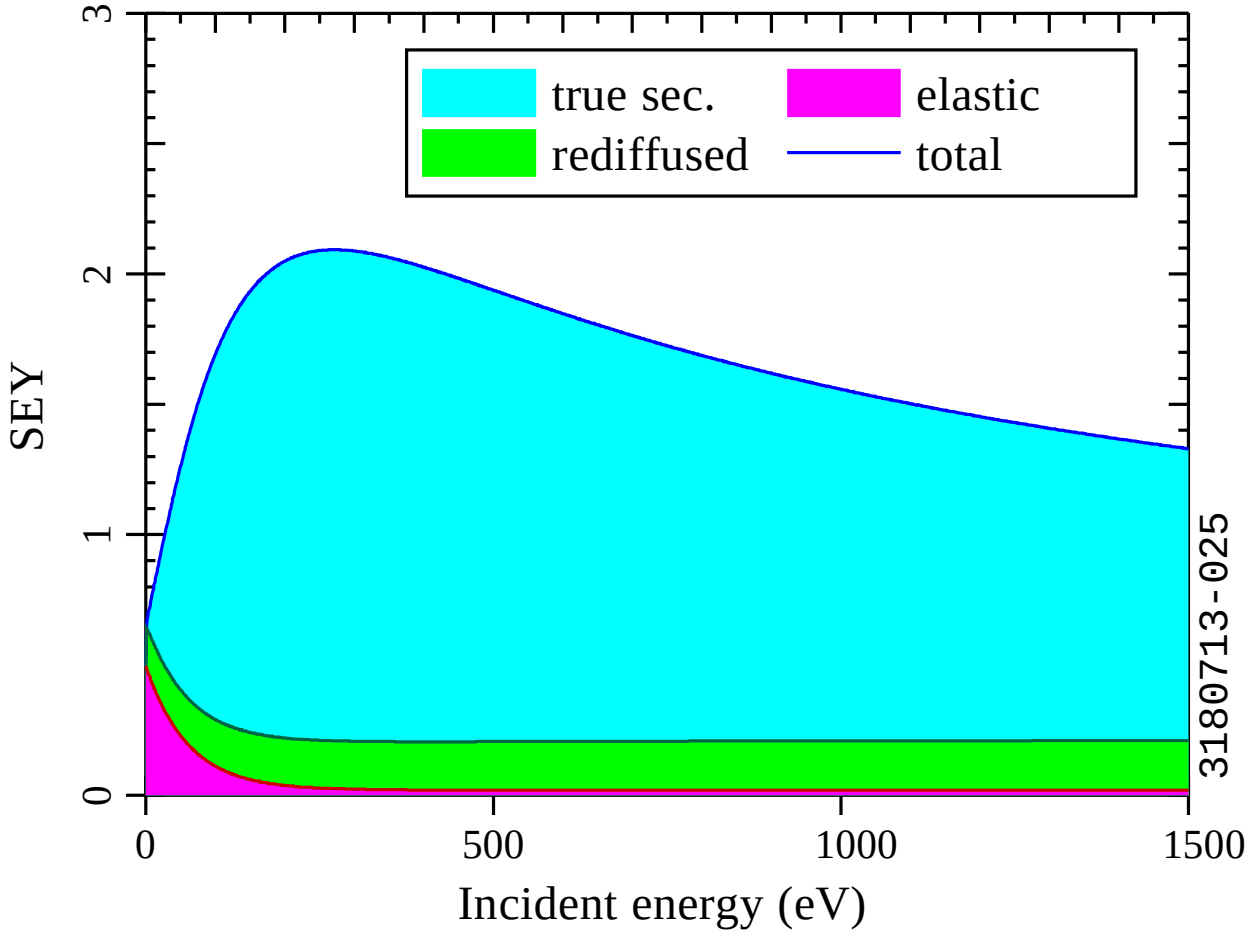
- Witness bunches sample the cloud left by the 10-bunch train.
- For both the SPU and QSPU, the decay time is similar.

Aside: QSPU Witness Bunch Detail



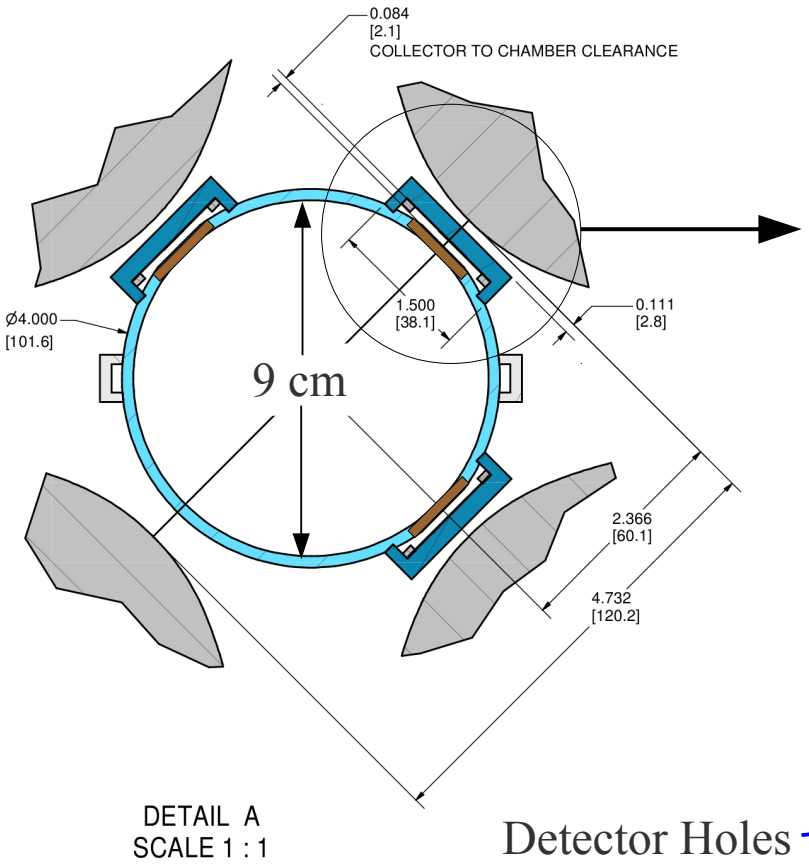
• This detail shows that there is a delay of about 18 ns between the arrival of the bunch and the peak electron signal.

Secondary Electron Yield

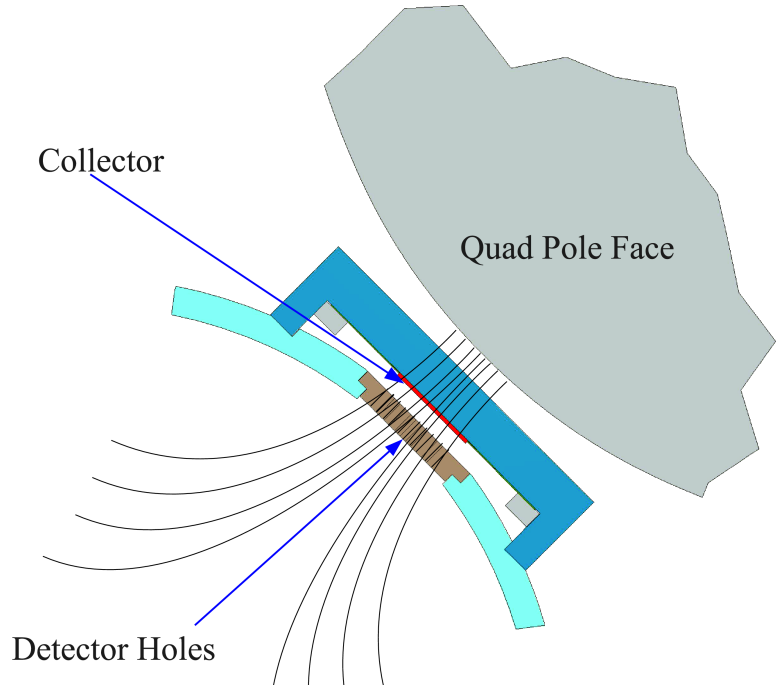


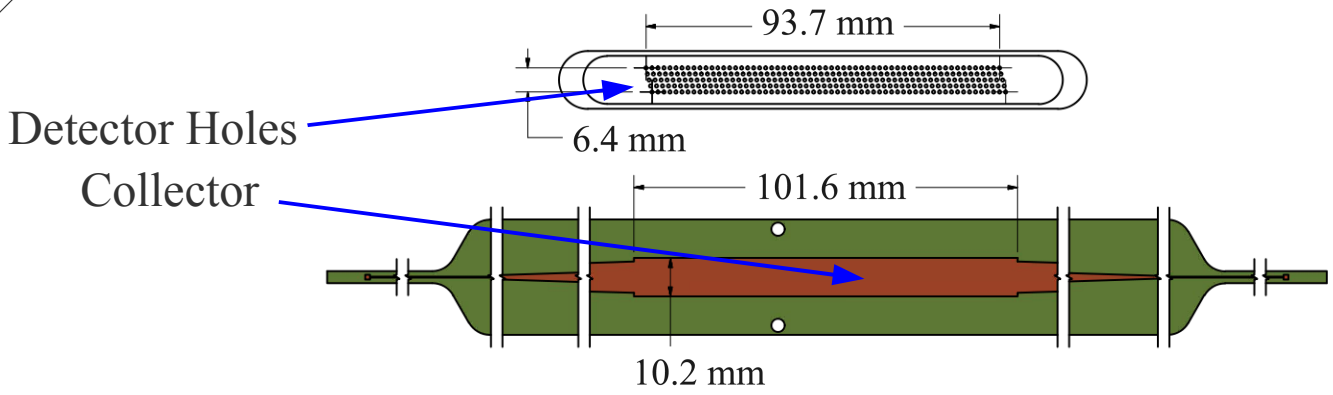
SEY vs incident energy at normal incidence for copper (using Cu parameters for SEY model from M. Furman & M. Pivi, PR-STAB 2002)

Quad Shielded Pickup (QSPU)



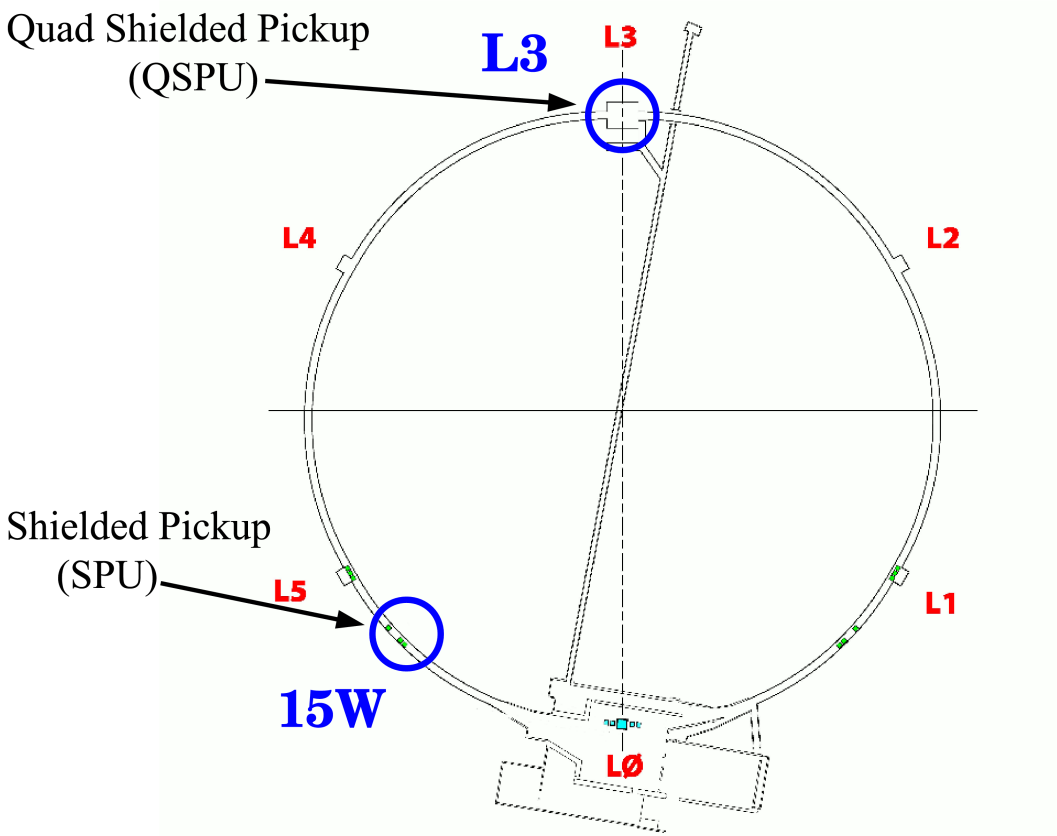
DETAIL A
SCALE 1 : 1





CESRTA Layout

CESRTA Storage Ring and Locations of Detectors



- The QSPU chamber is stainless steel in a quad with 7.4 T/m field.
- The SPU is in an aluminum chamber coated with TiN (field free).
- The revolution time of the stored beam is 2.562 μs.