Electron Cloud Diagnostics and Measurements

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Afternoon Session

Electron Cloud Studies in the Fermilab Main Injector Using Microwave Transmission

- 3 microwave methods: direct phase shift, sideband spectrum off of a carrier wave, zero span
- Potential for Laser interferometry?
  - Potentially much larger phase shift (~lambda)
  - How to get a laser light in?
    - Transversely?
    - Angled through antechamber in Wigglers?
  - Evaluate this technique for a "realistic" geometry
- Effect of reflections: How do you know what you're seeing? Could be getting reflections from lots of places.
- What is the difference for round pipes?

TE-wave Measurements at CesrTA

- Shielded Pick Up and TE give different results
  - TE sees more electrons than SPU
  - Some electrons remain in beam region for a long time (>140 ns)
- TE sees lots of reflections and other regions of beam pipe than were wanted. Some cloud regions may get double-counted.
- Clearing solenoid has no effect on TE or SPU.
  - Why? (No secondaries due to coating?)
- TE Resonance measurements
  - For electron cyclotron motion in chicane magnet field, observe Amplitude modulation - Is this useful information? Can we see B=0 regions in Wigglers?
  - Need a formulation for this method
- Simulation of "accelerator junk" in beam pipe can help in understanding how TE wave propagates – How well can be done?
- Mini phased array can provide better directionality, avoid looking at areas outside that between the input and pickup

E-cloud Measurements at the Main Injector

- Electron cloud density peaks during energy ramp, but disappears by the end of the ramp cycle. Why? Bunch length?
  - Magnetic field strength? (Due to power cables?)
    - Mu-metal shield only had a small effect
- What is the sensitivity for changes in SEY after vacuum incursions for different surface coatings?

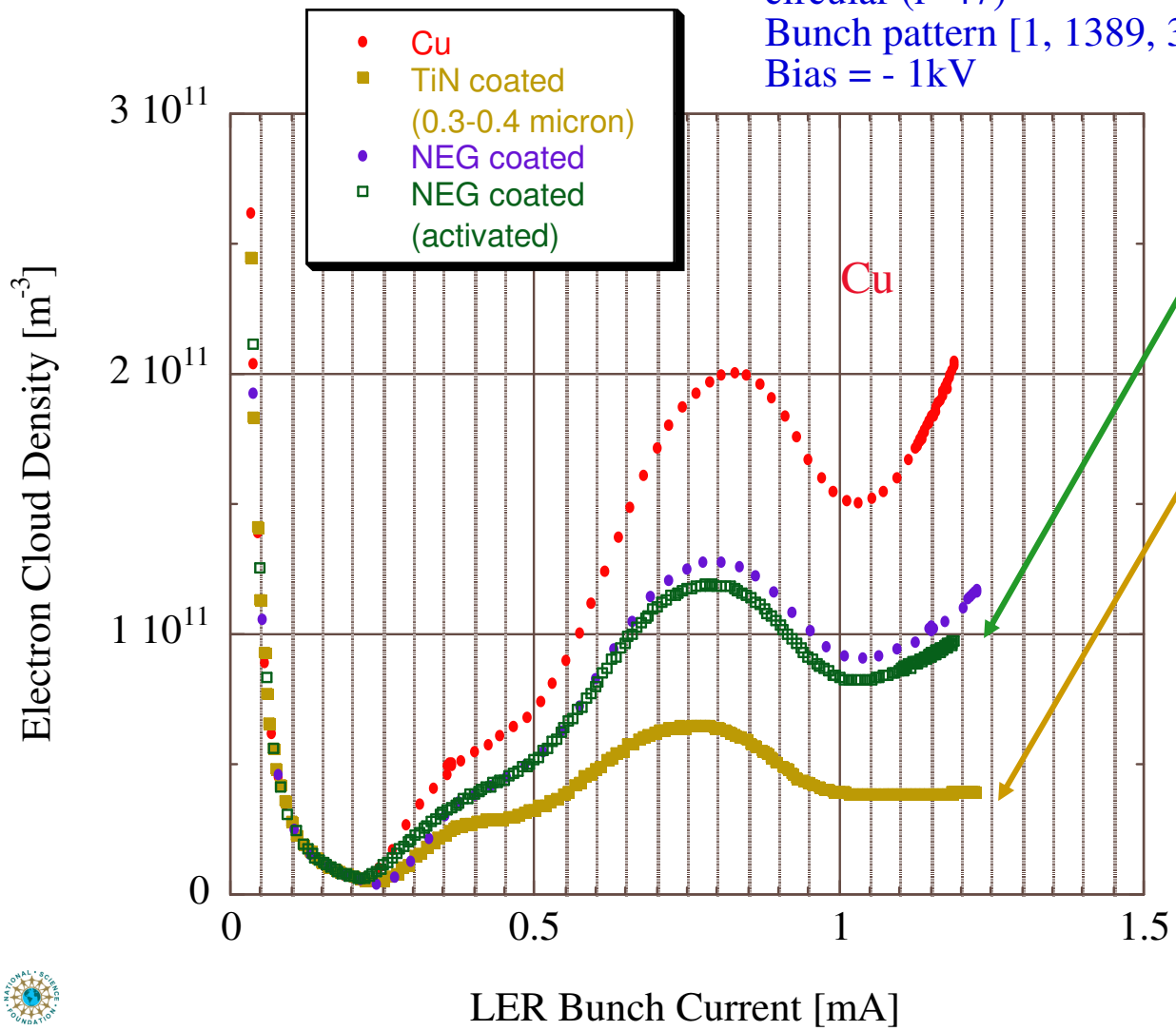
Analysis of the Electron Cloud Density Measurement with RFA in a Positron Ring

- Cloud density measurements with biased RFA
- Calculate phase space distribution around beam, assumes average momentum times velocity distribution + position distribution.
  - Analytic model compares well with numerical calculation of cloud density
- Don't have analytic evaluations for quadrupole and solenoid fields yet, only for drift space.
  - Can this be accomplished?
  - Do have numerical estimations
- Other issues for study:
  - Efficiency of RFA in magnetic field
  - Photo-electrons from grid
  - Could Joe Calvey's simulations, which include RFA structure as well as the beam pipe and magnetic fields, help with estimating the more complicated cases than simple drift space?
  - Why is there a bump in the E cloud density at lower currents? (Next slide)

Estimation of the electron cloud density in a drift space

Effect of coatings

a ~ 0, D8 straight
circular (r=47)
Bunch pattern [1, 1389, 3.5]
Bias = - 1kV



Direct synchrotron radiation is negligible here (a ~ 0).

Multipacting process is dominant.

NEG coating (SAES Getters)

TiN coating (R. J. Todd and H. C. Hseuh , BNL)

TiN reduces the density to about one thirds compared to raw copper and is more effective than NEG.

COLDDIAG: A Cold Vacuum Chamber for Diagnostics

- Beam heat load sources:
  - SR
  - Resist wall heating
  - RF effects (proportional to I^2, affected by fill pattern etc.)
  - Electron or ion bombardment
- Instrumentation:
  - Temperature sensors
  - Pressure gauges
  - Residual gas analyzers
- Can also measure electron flux onto beam tube
- Gas on surface affects heating?
  - Pressure of various regions outside of COLDDIAG may affect gas layer composition inside COLDDIAG – how to monitor/control?
- Background current from RFA is very high. Too high a noise level?
  - Continue investigating how to reduce high noise level in the RFA.
- When you deposit gas on surface, is there a diagnostic for how many mono-layers were actually deposited?
  - Study cryo-pumped gas composition by reheating chamber. Can this also be used to study the gas composition after beam operations?

Electron Cloud Generation, Trapping and Ejection From Quadrupoles at the Los Alamos PSR

- Electron mirror installed upstream of quad
  - Simulation shows effectiveness in trapping electrons
- RFA placed inside quadrupole
- Drift space and quadrupole have comparable electron cloud densities despite quadrupole having lower multipactor gain, due to more seed electrons. (Quads are near dipoles.)
- Long decay time for electrons trapped in quad
  - 59-98 μs, depending on beam charge
  - Why does decay time depend on beam intensity? Something else changing?
- Puzzle: measured dependence of cloud density on beam intensity is greater than that expected from simulation
- Lines seen on walls of dipoles and quadrupoles
  - Width of line in quadrupoles follows simulation, assuming cutoff energy of 250 eV. Determine composition for actual chamber(s).

E-cloud Measurements at the Main Injector

- Tan's initial comment about his presentation instigating a "food fight."
- At out table we thought seriously about this, but were soothed by the jazz saxophone and forgot all about the food fight.